RI02899F

ENGINEERING EVALUATION/COST ANALYSIS

MOHAWK TANNERY SITE
NASHUA, NEW HAMPSHIRE

RESPONSE ACTION CONTRACT (RAC), REGION I

For
U.S. Environmental Protection Agency

By
Tetra Tech NUS, Inc.

EPA Contract No. 68-W6-0045
EPA Work Assignment No. 118-NSEE-01C7
TtNUS Project No. N4111

July 2002

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TABLE OF CONTENTS
ENGINEERING EVALUATION/COST ANALYSIS
MOHAWK TANNERY SITE
NASHUA, NEW HAMPSHIRE

SECTION **PAGE**

TABLE OF CONTENTS (cont.)
ENGINEERING EVALUATION/COST ANALYSIS
MOHAWK TANNERY SITE
NASHUA, NEW HAMPSHIRE

TABLE OF CONTENTS (cont.)
ENGINEERING EVALUATION/COST ANALYSIS
MOHAWK TANNERY SITE
NASHUA, NEW HAMPSHIRE

SECTION | **PAGE**

TABLES

NUMBER

TABLES (cont.)

NUMBER

TABLE OF CONTENTS (cont.)
ENGINEERING EVALUATION/COST ANALYSIS
MOHAWK TANNERY SITE
NASHUA, NEW HAMPSHIRE

TABLES (cont.)

NUMBER

FIGURES

NUMBER

FIGURES (cont.)

NUMBER

REFERENCES

APPENDICES

LIST OF ACRONYMS

ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
CDD	Chlorinated Dibenzo-p-dioxins
CDF	Chlorinated Dibenzofurans
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CSF	cancer slope factor
DHHS	Department of Health and Human Services
ECG	electrocardiograph
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
EPC	exposure point concentrations
ERA	ecological risk assessment
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic model
IRIS	Integrated Risk Information System
kg	kilogram
mg	milligram
MSL	mean sea level
NHDES	New Hampshire Department of Environmental Services
NTCRA	non-time critical removal action
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PRG	Preliminary Remediation Goal
PRSC	post-removal site control
ppbv	parts per billion by volume
RAOs	Removal Action Objectives

RfD	reference dose
SERA	screening-level ecological risk assessment
SSAF	Soil-to-skin adherence factor
SVOC	semi-volatile organic compound
TBCs	Criteria and Guidance To Be Considered
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF	Toxicity Equivalence Factor
TEQ	Toxicity Equivalent
UCL	Upper Concentration Limit
ug	microgram

E.0 EXECUTIVE SUMMARY

This report presents the findings of the Engineering Evaluation/Cost Analysis (EE/CA) conducted in support of a Non-Time-Critical Removal Action (NTCRA) for the Mohawk Tannery Site. The report was prepared by Tetra Tech NUS, Inc. (TtNUS) for the U.S. Environmental Protection Agency (EPA), Region I, under Work Assignment No. 118-NSEE-01C7, Contract Number 68-W6-0045. The decision to proceed with the EE/CA was documented in the Approval Memorandum signed by EPA on July 12, 2000.

E.1 Site Background

The following presents a description of site features, a summary of the site's operational history, and a brief description of previous investigations that have been performed at the site.

E.1.1 Site Description

The Mohawk Tannery Site is located in the City of Nashua, Hillsborough County, New Hampshire. The site is bordered by the Nashua River to the west, a closed landfill to the north, and residential areas to the east and southeast.

The site is the former location of a leather tannery facility. Several structures used in tannery operations, as well as debris from several demolished structures, remain on site. Remaining structures include the main facility building and a smaller control building attached to the main building. Also remaining on the west side of the site, alongside the Nashua River, is an open lagoon that was part of the facility's wastewater treatment system (the open lagoon is also referred to as Disposal Area 1).

The site slopes steeply toward the Nashua River, with a topographic relief of approximately 70 feet from the eastern boundary of the site to the western boundary along the river. Groundwater was measured between 7 and 14 feet below ground surface in monitoring wells located along the Nashua River, and approximately 70 feet below ground surface in the eastern portion of the site.

The Nashua River flows from north to south along the western border of the site. A former lagoon that has since been covered with soil (Disposal Area 2), is located adjacent to the river, within the river's 100-year floodplain. The Area 1 open lagoon is not located within the 100-year floodplain due to the elevation of the man-made soil berm around its perimeter. If the berm was ever breached during a major flood event, then the contents of the lagoon, which are located below the 100-year flood elevation, could be washed into the river.

E.1.2 Operational History

The Mohawk Tannery, also known as Granite State Leathers, operated at the site from 1924 to 1984. While in operation, the facility used several hazardous substances in the preparation and tanning of animal hides. Substances used included volatile organic compounds (VOCs), inorganic metals, chlorinated phenols, and alkaline and acidic solutions. The facility produced waste streams containing spent chromium, as well as VOCs, chlorinated phenols, proteinaceous solids (e.g. hair and hide scraps), alkaline and acid residuals, mineral solids, and undissolved lime.

Over the course of its operational history, the Mohawk Tannery used the Area 1 and Area 2 lagoons for several functions as part of the treatment process for tannery effluent. Sludge from the lagoons was periodically dredged and disposed of in four disposal areas at the site, referred to as Disposal Areas 3 through 6.

The use of the Area 2 lagoon is believed to have been discontinued at some time during the 1970s. The lagoon was reportedly covered with a layer of 4 to 12 inch diameter logs (which were not encountered during subsurface explorations performed as part of the EE/CA) and a layer of fill. Area 2 has since been allowed to naturally revegetate.

In approximately 1980, materials including hide scraps and other miscellaneous refuse were excavated in preparation for constructing the control building for a new treatment facility. The excavated materials were moved approximately 30 to 125 feet southwest of the building, to an area identified in the EE/CA as Area 7.

During the early 1980s, dried sludge from the facility was placed into a PVC-lined landfill on the adjacent Fimbel Door Company property (Fimbel Landfill). Since 1984, Disposal Areas 3 through 7 have been covered with sand and gravel and allowed to naturally revegetate. The Fimbel Landfill has been capped with a low permeability cover and closed under New Hampshire State Regulations, and was not evaluated as part of the EE/CA.

E.1.3 Previous Investigations and Removal Actions

In April 1985 an initial characterization of subsurface conditions was performed to support future site use subsequent to the closure of Granite State Leathers. Investigative activities included a review of data provided by Granite State Leathers pertaining to tannery processes and waste streams; site plans depicting the locations of treatment facilities; and information on soil, groundwater, and surface water conditions at the site. Subsurface exploration activities included the excavation of 36 test pits, advancement of one soil boring, and collection of one groundwater sample. This report provided information on the operational history of the tannery and a preliminary description of the nature and extent of contamination at the site.

A Phase II hydrogeological study at the site was performed in June 1985 to further characterize site conditions and provide recommendations for containment of tannery sludge/waste. Subsurface investigative activities included the excavation of additional test pits in previously identified sludge disposal areas, advancement of 12 soil borings and installation of 10 monitoring wells, advancement of 2 hand-driven borings within the open lagoon (Area 1), and estimation of hydraulic conductivity through the collection of selected soil samples.

EPA conducted a time-critical removal action at the site beginning in September 2000 and concluding in January of 2001. Actions taken included the removal and disposal of asbestos-containing material from the old tannery building; characterization and disposal of the contents of 42 drums, a large above ground storage tank, and a large clarifier tank on the site; and removal of approximately 110 empty drums and 360 laboratory-type containers and disposal of them at an off-site facility. EPA also repaired a number of gates at the site and posted warning signs about the dangers of trespassing, to better secure the site.

In October 2000, samples of sludge were collected from Areas 1 and 2 (by a consultant for a potential property buyer) in an effort to characterize waste for disposal purposes. Analytical results revealed that none of the sludge samples exhibited a RCRA hazardous waste characteristic. The report concluded that, based on waste characteristic data evaluated during this study, the sludge could be transported to and disposed of at an EPA and NHDES-approved local landfill.

E.2 EE/CA Field Investigation

In August/September 2001, TtNUS performed a field investigation to support the EE/CA. The overall objectives of the field investigation were to collect analytical and field observation data to support a streamlined human health and ecological risk evaluation and the development and evaluation of NTCRA alternatives for the sludge and associated soils in each waste disposal area on the site. In January 2002 EPA conducted limited additional sampling to to support the ecological risk evaluation. The following is a summary of field investigation activities and findings.

E.2.1 Field Investigation Activities

Test pit explorations were conducted in Areas 2 through 7 to better define the horizontal boundaries of the former tannery waste disposal areas, determine the thickness of soil cover over the sludge, and if possible, to determine the sludge thickness at the disposal area boundaries. Test pits were not used to collect sludge/soil samples for laboratory analysis.

Subsequent to the excavation of test pits, several observation borings were advanced using direct-push technique (DPT) drilling in Areas 2, 3, 5, 6, and 7. Observation borings were used to collect further information to delineate the lateral extent of sludge waste, and to aid in the determination of the thickness and volume of sludge and overlying soil in each disposal area. No soil samples were collected for laboratory analysis from observation soil/sludge borings.

Finally, a total of 25 sludge/soil borings were advanced using manual coring techniques and DPT drilling for the purpose of obtaining sludge and soil samples for chemical analysis and determining the thickness of sludge and cover soils in each disposal area. The borings located in Area 1, the open lagoon, were advanced from a floating work platform using manual coring techniques. The borings in the remaining areas were advanced using DPT drilling.

Additional field activities performed by TtNUS in autumn 2001 that were not related to the determination of the nature and extent of sludge/waste included a wetland delineation, endangered/threatened species evaluation, water table measurement collection and inventory of existing wells, and topographic/land survey.

Two surface water samples were collected by EPA in January 2002 from the Area 1 lagoon. The purpose of the sampling was to obtain chemical characterization data for the surface water in the lagoon in support of the streamlined ecological risk evaluation.

E.2.2 Field Investigation Findings

Sludge and soil sample analytical results were compared to EPA Region IX Preliminary Remediation Goals (PRGs) for residential soil, New Hampshire Department of Environmental Services (NHDES) Risk Characterization and Management Policy (RCMP) Method 1 Standards for Category S-1 Soil, and NHDES RCMP background concentrations of metals in soils in order to identify contaminants of potential concern for the EE/CA. Surface water analytical results were compared to water quality criteria from EPA and Oak Ridge National Laboratory to identify contaminants of potential ecological concern.

The screening of analytical data from sludge samples revealed the presence of several contaminants including, but not limited to, carbon disulfide, benzo(a)pyrene, 2-methylnaphthalene, 4-methylphenol, pentachlorophenol, dioxins toxicity equivalents (TEQs), antimony, arsenic, and trivalent chromium at concentrations exceeding screening criteria. Hexavalent chromium was not detected at concentrations exceeding screening criteria.

Overlying soils (e.g. the fill material placed over some of the sludge disposal areas) only exceeded screening criteria for metals. The organic compounds typical of sludge/wastes across the site were detected in overlying soils only sporadically, and at concentrations below screening criteria. Overlying soils exceeded screening criteria for antimony, arsenic, and chromium.

Underlying soils (e.g. the soil beneath observed sludge in the disposal areas) only exceeded screening criteria for arsenic, which may be present due to background conditions. The organic compounds typical of sludge/wastes across the site were detected in site soils only sporadically, and at concentrations below screening criteria. The underlying soils are typically present at depths greater than 10 feet bgs, and therefore are not likely to be accessible for human exposure.

Based on detected levels in two surface water samples from Area 1, surface water exceeded identified screening criteria for several contaminants including carbon disulfide, 4-methylphenol, pyrene, chromium, manganese, and selenium.

The wetland delineation identified two wetland areas on the undeveloped, southern portion of the Mohawk Tannery property. No wetlands were identified on the developed northern parcel.

Federal and State agencies contacted for the endangered and threatened species evaluation did not identify any recorded occurrences of threatened or endangered species in the immediate vicinity of the site, with the exception of “occasional transient bald eagles”. However, since many areas of the state have not been surveyed, the lack of positive identification is not definitive proof that no sensitive species are present.

Water table measurements collected in October 2001 indicated that groundwater was encountered between 7 and 14 feet bgs at the western end of the site along the Nashua River. An evaluation of groundwater elevation versus observed sludge depth indicates that sludge is currently located beneath the water table only in Areas 1 and 2. Based on October 2001 conditions, as much as 6 feet of sludge is likely to be submerged in Area 1 and up to 9 feet of sludge in Area 2. More sludge in these areas, as well as sludge in other areas (particularly Area 3) may become submerged as the water table rises. The October 2001 conditions are believed to represent seasonal low groundwater conditions.

E.3 Streamlined Human Health and Ecological Risk Evaluations

Streamlined human health and ecological risk evaluations were conducted to determine whether site contaminants are likely to pose a risk to humans and ecological receptors. Both evaluations concluded that contaminants in site sludge/waste and surface soils pose a potential risk to humans and ecological receptors under current and future exposure scenarios. The following is a summary of the risk evaluation findings.

E.3.1 Streamlined Human Health Risk Evaluation Results

The streamlined human health risk evaluation was performed to identify the risk to humans from soil and sludge at the site. The evaluation was conducted using standard quantitative risk assessment methods, except that it focused only on media of concern for the NTCRA. Other media (groundwater, surface water, air) were not evaluated.

The human health risk evaluation identified potential human health risks above EPA's target non-cancer hazard index (H1) of 1.0 and/or cancer risk level (CR) of 1.0×10^{-4} for the following receptors and exposure scenarios:

- Current or future adolescent trespasser exposed to wet sludge in Area 1: HI of 42.5, CR of 1.86×10^{-3}

- Future lifetime resident exposed to surface soil in Areas 2 through 7: HI of 13.1, CR of 9.54×10^{-5}

- Future lifetime resident exposed to surface and subsurface soil/sludge in Areas 1 through 7: HI of 72.4, CR of 1.87×10^{-4}

The major contributors to excess non-cancer risks are 4-methylphenol, arsenic, antimony, cadmium, and manganese. The major contributors to excess cancer risks are dioxins, pentachlorophenol, arsenic, and benzo(a)pyrene. Benzo(a)pyrene was detected only in a very localized area of the site, in one sample from Area 7. It does not appear to be a site-wide concern.

E.3.2 Streamlined Ecological Risk Evaluation Results

The streamlined ecological risk evaluation is a screening-level evaluation that uses conservative screening values to identify all contaminants that may pose an ecological risk. Contaminant concentrations are compared against screening values to identify contaminants of potential concern (COPCs). COPCs do not necessarily pose a risk to ecological receptors, but rather indicate a potential risk that may warrant further investigation. The degree of potential risk posed by each contaminant is evaluated using hazard quotients (HQs). The HQ is the ratio of the contaminant concentration at the exposure point to its screening value. An HQ of greater than 1.0 indicates that adverse impacts are possible.

The ecological risk evaluation identified potential risks to ecological receptors from exposure to wet sludge (considered sediment in the ecological evaluation) and surface water in Area 1 and surface soil in Areas 2 through 7. The evaluation identified numerous contaminants of potential concern (COPCs) in each media. COPCs for sediment and surface soil included multiple contaminants from each of the following contaminant classes: VOCs, SVOCs, pesticides, dioxins, and metals. COPCs for surface water included only one VOC, two SVOCs, and three metals.

The maximum HQs identified for the Area 1 sediment were 35,000 (4-methyphenol), 30,400 (chromium), and 2,293 (carbon disulfide). The highest HQs for Area 2 through 7 surface soil were 8,823 (mercury), 1741 (aluminum) 528 (chromium), 298 (1,2,3,4,6,7,8-HpCDD dioxin), 200 (iron), and 179 (antimony). The highest HQ for surface water was 42 (manganese) followed by 5.4 (carbon disulfide). Although the ecological HQs were calculated using conservative screening values, the magnitude of the HQs calculated for sediment and surface soil at the site indicates that contaminants at the site pose a real concern for ecological receptors.

E.4 <u>Volume of Sludge/Waste to be Addressed by the EE/CA</u>

The results of the streamlined human health risk evaluations were used to select contaminants of concern (COCs) and preliminary remediation goals (PRGs) for the NTCRA. The PRGs were used to estimate the volume of waste that will be addressed by the EE/CA. The ecological risk evaluation was not used in the selection of COCs and PRGs because it was a screening-level evaluation only and therefore could not be used to definitively identify COCs or determine numerical cleanup standards.

E.4.1 Selection of Contaminants of Concern

The COCs identified for the site are compounds that posed an excess carcinogenic risk greater than 1.0E-6 or an excess non-carcinogenic risk indicated by a hazard index greater than 1 for any exposure scenario. The COCs identified for the site are identified on the table in Section E.4.2.

E.4.2 Identification of Preliminary Removal Goals (PRGs)

PRGs for site sludge/waste and soil were developed using risk-based values calculated from exposure scenarios identified in the streamlined human health risk evaluation; available guidance for addressing dioxin contamination; and the NHDES RCMP background concentrations of metals in soils. For all COCs except dioxins, the proposed PRG was selected from the lower of the risk-based PRGs corresponding to a cancer risk level of 1.0×10^{-6} and a hazard index of 1.0, unless this risk-based value was lower than the NH RCMP background concentrations of metals in soil, in which case the background concentration was selected as the proposed PRG. For dioxins, the proposed PRG was selected based on the EPA OSWER Directive Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (EPA, 1998).

Because the scope of the proposed NTCRA is limited to source control for contaminated soils, sludges, and wastes, PRGs were not developed for groundwater, surface water or river sediments. These media will be evaluated in the RI/FS scheduled to begin later this year.

Contaminants of Concern	Proposed PRG	Units
Benzo(a)Pyrene	145	ug/kg
Pentachlorophenol	6958	ug/kg
4-Methylphenol	712891	ug/kg
Dioxin TEQ	1000	ng/kg
Antimony	73	mg/kg
Arsenic	51	mg/kg
Barium	12780	mg/kg
Cadmium	82	mg/kg
Chromium III	273750	mg/kg
Manganese	12775	mg/kg
Vanadium	1278	mg/kg

E.4.3 Estimated Volume of Sludge/Waste to be Addressed by EE/CA

Sample analytical results were compared with proposed PRGs to estimate the volume of sludge/waste and soil to be addressed under the NTCRA. The following table provides a summary of the estimated volumes of sludge/waste in each disposal area that contain COCs at concentrations exceeding PRGs. No evidence of sludge/waste was observed in Area 5 during field investigation activities and samples collected from Area 5 did not exceed any of the proposed PRGs. As a result, no sludge/waste volume was estimated for this area. Overlying and underlying soil concentrations did not exceed the proposed PRGs, so no sludge/waste volume was assumed for the soils.

Disposal Area	Estimated Volume of Sludge/Waste (CY)
Area 1	25,185
Area 2	29,630
Area 3	370
Area 4	1,000
Area 6	648
Area 7	3,556
TOTAL VOLUME:	60,389

E.5 Removal Action Objectives (RAOs)

RAOs were developed that are protective of human health and the environment and consider potential future use of the site. These removal action objectives are presented below.

- Prevent, to the extent practicable, direct contact with, ingestion of, and inhalation of contaminants in tannery sludge/waste and associated soil at concentrations exceeding PRGs.

- Prevent, to the extent practicable, ecological receptor exposure to contaminants exceeding PRGs in tannery sludge/waste and associated soil.

- Prevent, to the extent practicable, migration of contaminants exceeding PRGs from tannery sludge/waste and associated soil to site groundwater and the Nashua River.

- Address tannery sludge/waste and associated soil with contaminants exceeding PRGs to restore the site to its intended use for residential purposes.

E.6 Development of Removal Action Alternatives

A screening of potential removal technologies and process options was performed to identify treatment, containment, or removal options that could meet the RAOs for the NTCRA. Technology types and process options were screened according to their potential effectiveness and implementability for treating site sludge/soil waste. The evaluation considered site-specific factors such as the nature of contaminated media, moisture content of sludge, contaminants present, location of wastes within the 100-year floodplain, and proximity to residential areas. The following three removal action alternatives were developed from the results of the screening:

- Alternative 1 – Excavation and Off-Site Disposal
- Alternative 2 – Consolidation into On-Site Landfill
- Alternative 3 – Excavation, Off-Site Treatment and Disposal

In April of 2002, the NHDES completed an updated hazardous waste determination for site sludge/waste using data gathered during the EE/CA field investigation. The data and the NHDES determination support the current assumption that sludge/waste from the site would not be considered a RCRA hazardous waste. However, based on the reactive sulfide concentrations found in Area 1 during the EE/CA investigation, it is possible that sludge/waste may be encountered in this area during implementation of the NTCRA that could cause the material to be considered a hazardous waste. As a result, a scenario under which the material from Area 1 would be considered as a RCRA hazardous waste was included in the EE/CA. Although it does not appear likely that the sludge/waste at the site will be classified as RCRA hazardous, a final decision on the regulatory status of the sludge/waste will be made during implementation of the removal action based on the results of the waste characterization samples collected from sludge/waste stockpiles during excavation.

The scenario for considering the Area 1 sludge/waste as a RCRA hazardous waste was included as a sub-option under Alternatives 1 and 2 because the regulatory status of the waste could significantly impact the implementability and cost of these alternatives. The regulatory status of the waste is not expected to impact the implementability or cost of Alternative 3, so the hazardous waste scenario was not evaluated for this alternative. However, the implementability and cost of Alternative 3 could be impacted by the limited number of incinerators within the United States that are able to accept dioxin-containing material. Accordingly, off-site treatment facilities within the United States and in Canada were evaluated as sub-options for Alternative 3.

E.7 Analysis of Removal Action Alternatives

Each of the three removal action alternatives presented above was analyzed individually to assess its effectiveness, implementability, and cost; and compared to the others to identify differences between the alternatives and analyze their comparative benefits and drawbacks. All alternatives offer similar degrees of protection and would achieve all of the removal action objectives established for this NTCRA. For each of the three alternatives, no residual contamination would remain at the site that would pose a risk to human health or the environment once the removal action was completed. Alternatives 1 and 3 would not require post-removal site control (PRSC) operations to maintain the protectiveness of the alternative, except for monitoring of restored vegetation until it is established. Alternative 2, unlike Alternatives 1 and 3, would consolidate and contain contaminated sludge/waste on site rather than remove it from the site and would require more extensive PRSC to monitor the integrity of the on-site landfill and prevent long-term impacts to human health and the environment. In addition, construction of an on-site landfill under Alternative 2 would place additional and permanent restrictions on how that portion of the site could be used thereby limiting the future use and development of the site to a greater extent than Alternatives 1 and 3.

Implementability issues related to excavation and removal of sludge/waste located below the water table would be the same for all three alternatives. On-site activities for Alternatives 1 and 3 would be identical, and both would be more easily implementable than those for Alternative 2 due to difficulties associated with the approval and design/construction of an on-site landfill within a residential area.

Considering implementability issues related to treatment or disposal sludge/waste, Alternative 1 would be the most easily implementable of the three alternatives, regardless of the final regulatory classification of sludge/waste from Area 1. Off-site disposal facilities (RCRA D, RCRA C, or outside the United States) that are willing and able to accept dioxin-containing waste have been identified during the EE/CA. Alternative 3 would be somewhat more difficult to implement because there are a limited number of incineration facilities permitted to accept dioxin-containing waste in both the United States and Canada and this may present some capacity issues. Obtaining the necessary approvals to transport waste to an incinerator is not expected to be difficult. Alternative 2 would be the most difficult to implement because of the anticipated difficulty in obtaining the required approvals to construct an on-site landfill in close proximity to a residential neighborhood and the Nashua River.

Under all cost scenarios considered, Alternative 2 is the lowest cost alternative. If the final waste determination allows for land disposal of the Area 1 sludge (regardless of whether the sludge is classified as non-hazardous or hazardous) Alternative 2 would be less than half the cost of Alternative 1. If the final waste determination concludes that the Area 1 sludge can not be land-disposed (due to the land disposal restrictions for dioxin-containing waste), the difference in cost between Alternatives 1 and 2 would reduce considerably, but Alternative 2 would still be less expensive. Under all regulatory scenarios, Alternative 3 would be the most expensive to implement by a large margin (between 2 and 5 times the cost of Alternative 1 and between 2 and 11 times the cost of Alternative 2). Alternative costs are summarized below.

COST ELEMENT	ALTERNATIVE 1: EXCAVATION and OFF-SITE DISPOSAL	ALTERNATIVE 2: CONSOLIDATION into ON-SITE LANDFILL	ALTERNATIVE 3: EXCAVATION, OFF-SITE TREATMENT, and DISPOSAL
Capital Costs	Alternative 1A: $14,939,000 Alternative 1B: $20,428,000 Alternative 1C: $22,819,000	Alternative 2A: $5,572,000 Alternative 2B: $5,572,000 Alternative 2C: $18,428,000	Alternative 3-US: $69,715,000 Alternative 3-CAN: $50,152,000
Annual PRSC Costs	Years 1-2: $4,000 Years 3-30: $0	Years 1-2: $155,275 Years 3-5: $60,075 Years 6-30: $37,275	Years 1-2: $4,000 Years 3-30: $0
Total Present Worth Costs	Alternative 1A: $14,946,000 Alternative 1B: $20,435,000 Alternative 1C: $22,826,000	Alternative 2A: $6,300,000 Alternative 2B: $6,300,000 Alternative 2C: $19,156,000	Alternative 3-US: $69,722,000 Alternative 3-CAN: $50,160,000

E.8 Recommended Removal Alternative

Based on the comparison of alternatives, Alternative 1 was selected as the recommended removal alternative. All alternatives met the NTCRA removal objectives and were protective of human health and the environment. Alternatives 1 and 3 fully satisfied the removal objective of restoring the site to future residential use; Alternative 2 only partially satisfied this removal objective because Alternative 2 would leave wastes on site in an on-site landfill, thereby restricting how the landfill area could be developed and used in the future. Although Alternatives

1 and 3 constituted a more permanent measure due to fewer PRSC requirements, all alternatives may be considered permanent and would be effective in the long term, provided that the on-site landfill (in Alternative 2) is properly operated and maintained and land use restrictions are enforced. Only Alternative 3 would satisfy the statutory preference for treatment.

The primary differences among the three alternatives lie in their implementability. Alternative 1 would be the most easily implemented. Several off-site landfill facilities in reasonably close proximity to the site are available to accept the volume of sludge/waste that is expected to be generated during the removal action. In addition, obtaining the necessary approvals for the off-site landfill disposal alternative is expected to present the fewest challenges from an administrative feasibility standpoint.

Alternative 2 would be much more challenging to implement than Alternative 1 due to the size of the on-site landfill that would be required to accommodate the volume of contaminated sludge/waste at the site and the potential for public opposition to an on-site landfill. Design and construction of a landfill that would be adequate to encapsulate 66,000 cubic yards of material would place considerably more constraints on how the site could be used and developed in the future and require more long-term efforts associated with PRSC. As a result, obtaining concurrence and acceptance from the State and public to construct an on-site landfill may be difficult.

Alternative 3 would be more difficult to implement than Alternative 1 because of the limited number of off-site treatment facilities within the U.S. and Canada that are permitted to receive dioxin-containing waste. Alternative 3 would be easier to implement than Alternative 2 because locating treatment facilities able to accept the waste and obtaining the necessary approvals for off-site incineration would present fewer challenges than obtaining concurrence and acceptance from the State and public to construct an on-site landfill.

Although Alternative 1 is only slightly more implementable than Alternative 3, it was selected as the preferred alternative because it would be considerably less costly. Off-site treatment at a Canadian incinerator (Alternative 3-CAN) would be the less expensive of the incineration options, but it would still cost over three times more than off-site disposal if Area 1 sludge were classified as non-hazardous waste; and more than two times more than off-site disposal if Area 1 sludge were classified as hazardous waste. For this reason, Alternative 1 (A, B, or C) is selected as the preferred removal action alternative, pending final waste determination and/or characterization results.

1.0 INTRODUCTION

This report presents the Engineering Evaluation/Cost Analysis (EE/CA) conducted for the Mohawk Tannery Site in Nashua, New Hampshire (the site). The U.S. Environmental Protection Agency (EPA) determined that an EE/CA was needed to evaluate potential threats to humans and the environment posed by tannery sludge/wastes in seven former lagoons and disposal areas at the site and to develop and evaluate potential non-time-critical removal-action (NTCRA) alternatives for the site. The work was conducted by TtNUS for EPA Region I, under Contract No. 68-W6-0045, Work Assignment 118-NSEE-01C7.

The EE/CA was prepared consistent with the requirements of all applicable laws, regulations, and guidance, including: the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR 300; and the Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA (EPA, 1993).

1.1 Purpose and Organization of Report

The purpose of this report is to present the results of the EE/CA process in order to provide EPA with sufficient information to justify the need for a NTCRA and select the preferred NTCRA alternative for the site. The report also presents the methods and results of the field investigation conducted to collect the data necessary to prepare the EE/CA.

Section 1.0 presents the introduction, provides a site description and historical information, and summarizes the field activities performed for the EE/CA. Section 2.0 summarizes the findings of the site investigations and the streamlined human health and ecological risk evaluations. Section 3.0 identifies contaminants of concern (COCs), selects preliminary remediation goals (PRGs), identifies the site conditions that justify a removal action, establishes the scope and objectives of the NTCRA, identifies regulatory considerations (ARARs), and presents a proposed schedule for NTCRA implementation. Section 4.0 documents the development of removal action alternatives and provides descriptions of the potential alternatives. Section 5.0 presents the detailed evaluation of removal action alternatives.

1.2 Site Background

This section presents the site description and operations history and describes previous removal actions that have been conducted at the site.

1.2.1 Site Description

The Mohawk Tannery site is located at the intersection of Fairmont Street and Warsaw Avenue in the City of Nashua, Hillsborough County, New Hampshire (Figure 1-1). The site is the former location of a leather tannery facility. The site consists of two contiguous properties: an approximately 15-acre developed parcel to the north, and an approximately 15-acre undeveloped parcel to the south. The site is bordered by the Nashua River to the west, a closed landfill to the north, and residential areas to the east and southeast. A chain link fence borders the developed portion of the site, except along the Nashua River side (Figure 1-2).

The inactive tannery facility is situated on the northern parcel. Several structures used in tannery operations, as well as debris from several demolished structures, remain on site. Remaining structures include the main facility building; a smaller control building attached to the main building; and portions of the former wastewater treatment system including a wood frame building housing a 60 foot long, 20 foot wide, 6 foot deep clarifier tank. Also remaining on the west side of the site, alongside the Nashua River, is an open lagoon that was part of the wastewater treatment system (TtNUS, 2001).

The site topography slopes steeply toward the Nashua River, with a topographic relief of approximately 70 feet from the eastern boundary of the site at Warsaw Avenue to the western boundary along the river. Groundwater was measured between 7 and 14 feet below ground surface in monitoring wells located in the vicinity of Areas 1 and 2, and approximately 70 feet below ground surface in the eastern portion of the site adjacent to Warsaw Avenue (GZA, 1985b).

Where it borders the site to the west, the Nashua River flows from north to south. The floodplain elevation along the Nashua River was determined to be 131 feet above mean sea level (MSL), referenced to North American Vertical Datum (NAVD) 1988. A large portion of Area 2 is located within the river's 100-year floodplain (Figure 1-2). The Area 1 Lagoon is not located within the 100-year floodplain due to the elevation of the berm that has been constructed around its perimeter. If the berm was ever breached during a 100-year flood event, then the contents of the lagoon, which are located below the 100-year flood elevation, could be released into the river during such a flood event.

1.2.2 Site History

The site history information presented in this section was obtained from the following documents: *Phase I Hydrogeologic Study, Granite State Leathers, Inc. Facility, Nashua, New Hampshire*, April 1985, prepared by Goldberg, Zoino and Associates (GZA) Inc. for Fairmont Height Associates; *Phase II Hydrogeologic Study and Conceptual Closeout Plan, Granite State Leathers, Inc. Facility, Nashua, New Hampshire*, October 1985, prepared by GZA for Fairmont Height Associates; and the Mohawk Tannery Site Approval Memorandum to perform an Engineering Evaluation/Cost Analysis for a Non-Time Critical Removal Action, USEPA, July 2000 (Appendix A; USEPA, 2000b).

The Mohawk Tannery, also known as Granite State Leathers, operated at the site from 1924 to 1984. While in operation the facility used numerous hazardous substances in the preparation and tanning of animal hides. Substances used included volatile organic compounds (VOCs), inorganic metals, chlorinated phenols, and alkaline and acidic solutions. The facility produced waste streams containing spent chromium, as well as VOCs, chlorinated phenols, proteinaceous solids (e.g. hair and hide scraps), alkaline and acid residuals, mineral solids, and undissolved lime.

Little is known about the tannery's effluent treatment practices prior to the 1960s. In general, industry practice prior to that time did not require treatment of wastes prior to discharge into nearby waterways. In the 1960s the facility began providing some treatment of waste prior to its discharge into the Nashua River. Two unlined lagoons were constructed along the western side of the site approximately 30 feet from the Nashua River and within its 100-year floodplain. Treatment in the lagoons (which are identified as Areas 1 and 2 on Figure 1-2) consisted of combining the acid and alkaline waste streams and allowing the solids to settle out before the liquid fraction was discharged to the river.

A separate treatment process for the alkaline and acid waste streams was put into use from around 1971 to 1981. The alkaline effluent was pumped sequentially into the Area 2 and Area 1 lagoons before being discharged to the river. The acid waste stream passed through a series of settling basins before being discharged to the river. The sludge from the lagoons and settling basins was periodically dredged and disposed of in four disposal areas at the site, identified as Areas 3 through 6 on Figure 1-2.

Between 1971 and 1981 a new treatment facility was constructed consisting of a control building, screen house, equalization tank, sulfide oxidation tank, primary clarifier, sludge dewatering unit with belt filter press, aerated lagoon (Area 1 lagoon), and a secondary clarifier. During construction, it was reported that sludge located in the general vicinity of the new primary clarifier (Area 6 on Figure 1-2) was transferred to Areas 3 through 5.

The use of the Area 2 lagoon was discontinued prior to completion of the new treatment system and the lagoon was reportedly covered with a layer of 4- to 12-inch diameter logs (which were not encountered during subsurface explorations performed as part of this EE/CA) and a layer of fill. Area 2 has since been allowed to naturally revegetate and is now covered with primarily herbaceous (non-woody) vegetation such as common reed.

In approximately 1980, materials including hide scraps and other miscellaneous refuse were excavated in preparation for constructing the control building for the new treatment facility. The excavated materials were moved approximately 30 to 125 feet southwest of the building, to the area identified as Area 7 on Figure 1-2.

From 1981 until the tannery closed in 1984, dried sludge from the facility was placed in a PVC lined landfill on the adjacent Fimbel Door Company property (Fimbel Landfill, identified on Figure 1-2). Since 1984, disposal Areas 3 through 7 have been covered with sand and gravel and allowed to naturally revegetate. In addition to granular fill, Area 5 was reportedly covered with a base layer of 6- to 12-inch diameter logs, similar to the reported cover on Area 2. These logs were not encountered during subsurface explorations performed during this EE/CA. The Fimbel Landfill has been capped with a low permeability cover and closed under New Hampshire State Regulations and was not included as part of the EE/CA.

In 1987, a release of aqueous material from the berm of the Area 1 lagoon was observed by the New Hampshire Department of Environmental Services (NHDES) during an inspection of the property. The property owner was ordered to determine the source of the release and conduct a study to characterize contamination at the site. No remediation of the site was conducted by the property owner (USEPA, 2000b).

1.2.3 Previous Removal Actions

EPA conducted a time-critical removal action at the site beginning in September 2000 and concluding in January of 2001. Actions taken included removing and disposing of asbestos-containing material from the old tannery building; characterizing and disposing of the contents of 42 drums, a large above ground storage tank, and a large clarifier tank on the site; and removing approximately 110 empty drums and 360 laboratory-type containers and disposing of them at an off-site facility. EPA also repaired a number of gates at the site and posted warning signs about the dangers of trespassing, to better secure the site.

1.3 Previous Investigations

This section provides brief descriptions of previous environmental investigations prepared for the site. EPA has determined that the data from these earlier investigations will not be used in the streamlined risk evaluations conducted as part of this EE/CA due to differences in the data quality objectives. However, the data will be used where appropriate in evaluating the nature and extent of sludge/waste at the site.

Phase I Hydrogeologic Study, Granite State Leathers, Inc. Facility, Nashua, New Hampshire, April 1985, prepared by Goldberg, Zoino, and Associates (GZA) Inc. for Fairmont Height Associates. GZA performed an initial characterization of subsurface conditions at the site in April 1985 in order to support future site use subsequent to the closure of Granite State Leathers. Investigative activities included a review of data provided by Granite State Leathers pertaining to tannery processes and waste streams; site plans depicting the locations of treatment facilities; and information on soil, groundwater, and surface water conditions at the site. Subsurface exploration activities performed in 1985 included the excavation of 36 test pits, advancement of one soil boring (which was converted to monitoring well GZ-1), and collection of one groundwater sample. TtNUS used this report as a source of information concerning the operational history of the site, waste handling and sludge disposal practices, geological conditions, and preliminary nature and extent of tannery sludge/waste.

Phase II Hydrogeologic Study and Conceptual Closeout Plan, Granite State Leathers, Inc. Facility, Nashua, New Hampshire, October 1985, prepared by GZA for Fairmont Height Associates. GZA performed a Phase II hydrogeological study at the site in June 1985 to further characterize hydrogeological conditions; further define the nature and extent of tannery sludge; define the nature and extent of overburden groundwater contamination; assess the potential impact of tannery sludge/waste on the Nashua River; and provide recommendations for containment of tannery sludge/waste. Subsurface investigative activities included the excavation of additional test pits in previously identified sludge disposal areas, advancement of 12 soil borings and installation of 10 monitoring wells, advancement of two hand-driven borings within the open lagoon (Area 1), and estimation of hydraulic conductivity through the collection of selected soil samples. Results of these investigations are summarized in the report submitted in October 1985. TtNUS used this report as an additional source of information pertaining to the nature and extent of tannery sludge/waste, as a preliminary source of groundwater elevation data, and as an initial source of information concerning the chemical nature of sludge/waste at the site.

Preliminary Sludge Characterization Investigation, Mohawk Tannery, 11 Warsaw Avenue, Nashua, New Hampshire, January 2001, prepared by GeoSyntec Consultants for Environmental Reclamation, Inc.: GeoSyntec collected samples of sludge from Areas 1 and 2 in an effort to characterize waste for disposal purposes. It was assumed that sludge from these areas is representative of waste located in Areas 3 through 7. Analytical results revealed that none of the sludge samples exhibited a RCRA hazardous waste characteristic. The report concluded that, based on waste characteristic data evaluated during this study, the sludge could be transported to and disposed of at an EPA- and NHDES-approved local landfill. TtNUS used data from this report to assist in characterizing the nature and extent of the tannery waste in Areas 1 and 2.

1.4 <u>EE/CA Field Investigation Activities Summary</u>

This section provides a summary of field investigation activities that were conducted by TtNUS in 2001 to support the EE/CA. A more detailed discussion of field investigation methods and objectives is presented in the Quality Assurance Project Plan (QAPP) (TtNUS, June 2001). The overall objectives of the field investigation were to collect analytical and field observation data to support a streamlined human health and ecological risk evaluation and the development and evaluation of NTCRA alternatives for the sludge and associated soils in each waste disposal area on the site. The specific goals of the field investigation were to:

- determine the nature, extent, and volume of sludge/waste and associated soils impacted by past waste disposal practices that may require removal;
- identify any on-site wetlands and endangered/threatened species that could be affected by actions taken at the site;
- collect topographic/land survey information needed to fully characterize the site and evaluate field data.

To meet the project objectives, the following field investigation activities were performed: test pit explorations; observation sludge/soil borings; sludge/soil borings for sampling and analysis; sludge sampling for air-headspace analysis; wetland delineation; endangered/threatened species evaluation; water table measurements and inventory of existing wells; and topographic/land surveying. These activities are described in the balance of this section. Field investigation results are presented in Section 2.

1.4.1 Test Pit Explorations

Test pit explorations were conducted to better define the horizontal boundaries of the former tannery waste disposal areas, determine the thickness of soil cover over the sludge, and if possible, determine the sludge thickness at the disposal area boundaries. Test pits were not used to collect sludge/soil samples for laboratory analysis.

The test pit investigation focused on Areas 2 through 7, the six sludge disposal areas that have been covered with soil. The horizontal limits of disposal Area 1, the open lagoon, were considered to be obvious and therefore did not require any further excavation. A total of 65 test pits were excavated at the site: fifteen in Area 2, ten in Area 3, nine in Area 4, ten in Area 5, ten in Area 6, and eleven in Area 7. Soils observed in each test pit were described on log sheets using the Unified Soil Classification System. All pertinent observations (depths and descriptions of sludge and soil, estimated grain size, dry vs. wet, etc.) were recorded, and photographs were taken. All test pit locations are depicted on Figure 1-3. Test pit locations for individual disposal areas are depicted on Figures 1-4 through 1-6. Test Pit Log sheets are contained in Appendix B.

1.4.2 Observation Borings

Subsequent to the excavation of test pits, several non-sampling (NS) observation borings were advanced using direct-push technique (DPT) drilling in Areas 2, 3, 5, 6, and 7. Observation borings were used to collect further information to delineate the lateral extent of sludge waste, and to aid in the determination of the thickness and volume of sludge and overlying soil in each disposal area. No soil samples were collected for laboratory analysis from observation soil/sludge borings.

A total of 19 observation borings were advanced at the site: four in Area 2, seven in Area 3, two in Area 5, four in Area 6, and two in Area 7. At each observation boring location, continuous samples were collected (using 4-foot length samplers) beginning at the ground surface and continuing to approximately 2 feet beyond the vertical limit of sludge (if encountered). Soil/sludge recovered from each sampler was described on boring logs using the Unified Soil Classification System. All pertinent observations (depths and descriptions of visually contaminated materials, grain size, moisture content, etc.) were recorded. Observation boring locations are depicted on Figures 1-3 through 1-6. Boring Log forms prepared during advancement of observation borings are contained in Appendix C.

1.4.3 Sludge/Soil Borings for Soil Sampling and Analysis

A total of 25 sludge/soil borings were advanced using manual coring techniques and DPT drilling for the purpose of obtaining sludge and soil samples for chemical analysis and determining the thickness of sludge and cover soils in each disposal area. The borings located in Area 1, the open lagoon, were advanced using manual coring techniques. The borings in the remaining areas were advanced using DPT drilling.

The general approach for locating borings for sampling and analysis was to divide each of the seven onsite disposal/lagoon areas into quadrants and advance one boring in the approximate center of each quadrant. This sampling approach was designed to yield representative sludge and soil samples from each area and to provide adequate spatial distribution to estimate sludge and soil volumes with an acceptable degree of accuracy for use in the EE/CA. Boring locations were adjusted in the field based on access considerations, field observations, and the estimated size of the disposal areas determined by test pitting activities and observation borings. The following is a summary of sludge/soil boring advancement and sample collection activities that were performed at each disposal area. Boring locations are depicted on Figures 1-3 through 1-6. Boring Log forms are contained in Appendix D. Analytical methods used are presented on Table 1-1. Sample analytical results are discussed in Section 2.1.

1.4.3.1 Area 1

Four borings were advanced in Area 1 (the open lagoon) from a floating work platform, using manual coring techniques (see Figure 1-4 for locations). Borings were advanced to refusal at each of the four sampling locations, and no underlying soil was recovered. Because of the challenges of obtaining samples from the open lagoon and the inherent limitations of manual coring, reaching refusal in these borings does not necessarily signify that bedrock was encountered. Based on the observed elevations of bedrock in nearby (non-manual) borings, it is unlikely that the manual borings in Area 1 reached bedrock.

Sludge recovered from each sampler was described on boring logs using the Unified Soil Classification System. All pertinent observations (depths and descriptions of visually contaminated materials, grain size, moisture content, etc.) were recorded.

One boring-composite sludge sample consisting of sludge from the entire length of the boring was collected from each boring. Each boring-composite sludge sample was shipped for laboratory analysis for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, and total sulfides. Additionally, one area-composite sludge sample (made up of sludge from all four Area 1 borings) was collected and shipped for laboratory analysis for RCRA hazardous waste characteristics for TCLP SVOCs, TCLP pesticides, TCLP metals, corrosivity, and reactivity. One paint filter test sample was collected from boring SL-104 based on observations of high moisture content of sludge. The paint filter test is used to determine the presence or absence of free liquids in a waste. The presence of free liquids in the sludge/waste would have an impact on materials handling and disposal options because wastes with free liquids can not be land-disposed without pre-treatment to dry or remove the liquids.

1.4.3.2 Area 2

Five sludge/soil borings were advanced in Area 2 due to the large area of sludge identified during the excavation of test pits and advancement of observation borings (see Figure 1-4). At each of the five boring locations, continuous sludge/soil samples were collected (using 4-foot length samplers) beginning at the ground surface and continuing through the entire thickness of the sludge and approximately 2 feet into the soils (or to refusal) beneath the sludge. At each boring, soils and sludge recovered from each sampler were described on boring logs using the Unified Soil Classification System. All pertinent observations (depths and descriptions of visually contaminated materials, grain size, moisture content, etc.) were recorded.

Sludge and soil samples for chemical analysis were collected from each of the five borings advanced in Area 2. Media that were sampled from these borings included tannery sludge, the cover soil above the sludge, and the bottom soil underlying the sludge. One boring-composite sample of sludge (from the entire sludge thickness) was collected from each of the five borings advanced in Area 2. Each of these samples was shipped for laboratory analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, and total sulfides. One paint filter test sample was collected from boring SL-205 based on observations of high sludge moisture. Additionally, one area-composite sludge sample (made up of sludge from each of the five borings) was collected and shipped for laboratory analysis for RCRA hazardous waste characteristics for TCLP SVOCs, TCLP pesticides, TCLP metals, corrosivity, and reactivity.

Samples were collected from soil both overlying and underlying the tannery sludge layer. One area-composite cover soil sample (made up of cover soil from all of the borings advanced in Area 2), and one area-composite underlying soil sample (made up of approximately 2 feet of soil underlying the sludge from borings SL-202, SL-204, and SL-205) were collected. Borings SL-201 and SL-203 met refusal prior to encountering underlying soils. Area-composite samples of overlying and underlying soil were shipped for laboratory analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, and total sulfides.

1.4.3.3 Areas 3 through 6

Three borings were advanced in each of these disposal areas (See Figures 1-4, 1-5, and 1-6). At each of the boring locations, continuous sludge/soil samples were collected (using 4-foot length samplers) beginning at the ground surface and continuing through the entire thickness of the sludge and approximately 2 feet into the soils beneath the sludge. At each boring, soils and sludge recovered from each sampler were described on boring logs using the Unified Soil Classification System. All pertinent observations (depths and descriptions of visually contaminated materials, grain size, moisture content, etc.) were recorded.

Sludge and soil samples for chemical analysis were collected from each boring. Media that were sampled from these borings included tannery sludge, the cover soil above the sludge, and the bottom soil underlying the sludge. One boring-composite sample of sludge was collected from each boring and shipped for laboratory analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, total sulfides, TCLP VOCs (grab sample), TCLP SVOCs, TCLP pesticides, TCLP metals, corrosivity, reactivity, and ignitability. The grab samples for TCLP VOC analysis were selected from the most contaminated sample interval within each boring, as determined by VOC headspace screening and/or visual observations. As proposed in the QAPP, one paint filter test sample (SL-402) was collected from these disposal areas based on observation of high sludge moisture content.

Sampling procedures in Areas 3 through 6 were adjusted in the field to accommodate the subsurface conditions encountered during the test pit explorations and advancement of observation borings. In Area 3, area-composite samples of overlying and underlying soil from all borings were collected and shipped for laboratory analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, and total sulfides. In Area 4, sampling procedures for overlying and underlying soils were the same as for Area 3, except that underlying soil was not collected from boring SL-401 due to boring refusal prior to encountering the vertical limit of sludge. In Area 5, due to the absence of an obvious sludge layer, no overlying or underlying soil samples were collected. All samples collected from Area 5 were identified as sludge samples for the purposes of data evaluation only. In Area 6, overlying and underlying soil area-composite samples were collected and shipped for analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, and total sulfides. The area-composite samples for Area 6 included soil from all borings, except soil from boring SL-603 was not included in the area-composite of overlying soil due to an ambiguous interface between overlying soils and tannery sludge/waste. An obvious layer of sludge was observed at a depth of 6 feet bgs in boring SL-603; however, traces of animal hides were observed in soils in this boring beginning at the ground surface.

1.4.3.4 Area 7

Four soil/sludge borings were advanced in Area 7 (see Figure 1-6). At each boring location, continuous sludge/soil samples were collected (using 4-foot length samplers) beginning at the ground surface and continuing through the entire thickness of the sludge and approximately 2 feet into the soils beneath the sludge. Soils and sludge recovered from each sampler were described on boring logs using the Unified Soil Classification System. All pertinent observations (depths and descriptions of visually contaminated materials, grain size, moisture content, etc.) were recorded.

Sludge and soil samples for chemical analysis were collected from each boring. Media that were sampled from these borings included tannery sludge, the cover soil above the sludge, and the bottom soil underlying the sludge. One boring-composite sample of sludge was collected from each boring and shipped for laboratory analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, total sulfides, TCLP VOCs (grab sample), TCLP SVOCs, TCLP pesticides, TCLP metals, corrosivity, reactivity, and ignitability.

Samples were collected from soil both overlying and underlying the tannery sludge layer in Area 7. One area-composite cover soil sample (made up of overlying soil from borings SL-701, SL-703, and SL-704), and one area-composite underlying soil sample (made up of underlying soil from all borings) were collected. The overlying soil composite for Area 7 did not include soil from boring SL-702 because signs of potential tannery waste and debris were observed beginning at the ground surface at this location. Area-composite samples of overlying and underlying soil were shipped for laboratory analyses for VOCs, SVOCs, pesticides/PCBs, metals, dioxins, hexavalent chromium, and total sulfides.

1.4.4 Sludge Sampling for Air-Headspace Analysis

Sludge/soil borings were also used to collect sludge samples for air-headspace analysis. The purpose of these samples was to evaluate potential air emissions that may result from excavation of the sludge during the NTCRA. The air data will be used in the EE/CA to identify and evaluate potential odor control technologies to address the expected air emissions that would be generated by excavation and handling of site sludge. Odor control is expected to be an important component of any removal action involving excavation of sludge because the sludge has a strong sulfide odor that could potentially impact residential properties in the site vicinity.

During the drilling/sampling program, grab sludge samples from distinct intervals in four borings were collected and shipped to a laboratory for headspace analysis for VOCs and odorous sulfides. Air headspace sample locations were selected in the field based on field observations and screening that indicated a potential for significant air emissions during excavation (e.g. strong odors and visual evidence of contamination). The sample interval was selected based on jar headspace screening results (the highest in a boring), or if the headspace screening was inconclusive, field observations of odors and/or visual evidence of contamination. In general, the grab samples for headspace analysis were collected from the same general vicinity as the VOC and TCLP VOC samples. Air headspace samples were collected from sludge in borings SL-104 (Area 1), SL-205 (Area 2), SL-403 (Area 4), and SL-704 (Area 7).

1.4.5 Wetland Delineation

The objective of the wetland delineation was to identify the current wetland boundaries and map the areal extent of the on site wetlands. The wetland delineation used the three parameter approach based on vegetation, soils, and hydrology described in the Corps of Engineers Wetlands Delineation Manual (COE Manual, Environmental Laboratory, 1987). The wetland delineation methods and results are presented in Section 2.1.4 of this report.

1.4.6 Endangered/Threatened Species Evaluation

The objective of the endangered/threatened species evaluation was to identify any rare or endangered species that may be present at the site. The evaluation was conducted through communications with federal and state agencies and through on-site observations. The endangered/threatened species evaluation results are presented in Section 2.1.5 of this report.

1.4.7 Water Table Measurements and Inventory of Existing Wells

TtNUS performed an inventory of existing groundwater monitoring wells to determine whether the wells would be useable for groundwater level measurements and possible future sampling. The inventory focused primarily on wells in the vicinity of the seven waste disposal areas and lagoons. Water table measurements were taken in all wells determined to be in adequate condition. Data from the water table measurements will be used to determine the elevation of the water table in the vicinity of the disposal areas. This information will be used in the planning and evaluation of removal alternatives to address the site sludge.

Monitoring wells GZ-1, GZ-4, GZ-6, GZ-9, GZ-10, and GZ-11 were determined to be in adequate condition and groundwater depths were recorded. Monitoring well GZ-12 was found to be destroyed and monitoring well GZ-13 was not functional due to an obstruction. Monitoring well GZ-7 and observation wells TP-1, TP2, TP-4, and TP-6 could not be located. All other monitoring wells and observation wells located on site were not part of the well inventory because they are outside the general vicinity of the disposal areas and are not of immediate concern for the purposes of the EE/CA. Results of the well inventory are summarized in Section 2.1.6 and detailed on the Well Inspection and Groundwater Level Measurement Sheets contained in Appendix E. Monitoring well locations are shown on Figure 1-3.

1.4.8 Topographic/Land Surveying

A topographic/land survey was conducted to verify the locations of important site features, spot-check the topographic contours, and identify selected sampling locations. Surveyed features were added to the digital-format site base map obtained from the City of Nashua, to provide an accurate depiction of the site for use in removal action evaluation and planning. The base map obtained from the city, entitled “Topographic Map of the City of Nashua, Hillsborough County, New Hampshire” was prepared by Chas. H. Sells, Inc. of Charlton, MA based on aerial photography dated April 13, 1998. The base map, with all boring and test pit locations, is presented as Figure 1-3.

1.5 Lagoon Surface Water Sampling by EPA

EPA personnel collected two surface water samples for chemical analysis from the Area 1 lagoon on January 30, 2002. The water samples were analyzed by the EPA New England Regional Laboratory for VOCs, SVOCs, pesticides/PCBs, total metals, and dissolved metals. The purpose of the sampling and analysis was to obtain chemical characterization data for the surface water in the lagoon for use in the streamlined ecological risk evaluation. Analytical results for the surface water samples are provided in Appendix F and discussed in Section 2.5.5.

2.0 DATA EVALUATION AND SITE CHARACTERIZATION

This section presents the results of site characterization efforts and the streamlined human health and ecological risk evaluations.

2.1 EE/CA Field Investigation Results

This section presents the results of the field investigation activities described in Section 1.0. In Sections 2.1.1 and 2.1.2, sludge, soil (overlying and underlying), and air headspace laboratory analytical results are presented in tabular form and compared to federal and state environmental standards and criteria. In Section 2.1.3, the analytical data and test pit logs, observation boring logs, and sample boring logs are interpreted to estimate the lateral extent and volume of waste present. Sections 2.1.4 and 2.1.5 document the results of the wetland and endangered species evaluations, respectively. In Section 2.1.6, water table measurements are used to estimate the volume of sludge located below the water table. Field results are presented by disposal area in the following sections.

2.1.1 Analytical Data Evaluation

Analytical data from sludge, soil, and air headspace samples were compared to project screening criteria selected from appropriate federal and state policies and regulations.

Screening criteria used to evaluate sludge and soil data are the EPA Region IX Preliminary Remediation Goals (PRGs) for residential soil and the New Hampshire Department of Environmental Services (NHDES) Risk Characterization and Management Policy (RCMP) Method 1 Standards for Category S-1 Soil. The S-1 soil category applies to soils with the highest potential for exposure. This includes accessible (surficial) soils in locations where children are present and may be exposed on a high frequency-high or low intensity basis, or a low frequency-high intensity basis, or where adults may be exposed on a high frequency-high or low-intensity basis. It also includes potentially accessible soil (2-15 feet below ground surface or shallower, if paved) where children may be exposed on a high frequency-high intensity basis. These criteria are considered appropriate for the site because it is zoned as residential property and abuts a residential neighborhood.

The Region IX PRGs are human health risk based criteria. Region IX PRGs for carcinogens are based on cancer risk levels of 1.0E-6. Region IX PRGs for non-carcinogens are based on a Hazard Index of 1.0. For consistency with the streamlined human health risk evaluation (which uses Region IX PRGs to identify contaminants of concern), the Region IX PRGs for non-carcinogens were adjusted to correspond to a hazard index of 0.1 (see Section 3.3 for details on the rationale for this adjustment). These adjusted values are presented in the data summary tables and used in evaluating the site data. The NHDES RCMP S-1 soil standards are derived to be protective of human health and of groundwater. The standards are the lower of the risk-based or leaching to groundwater-based criteria for each chemical.

In addition to the criteria identified above, soil samples were compared to NHDES RCMP background concentrations of metals in soils. Published RCRA criteria were used as screening criteria for TCLP analyses. NHDES 24-hour ambient air limits (AALs) were used as screening criteria for the air headspace analysis results.

Summaries of detected compounds in sludge, soil, and air samples collected at the site, and a comparison of analytical results to project screening criteria are presented on Tables 2-1 through 2-17. Analytical data results are contained in Appendix G.

In the following sections, contaminants that exceeded one or more screening criteria are identified. These exceedances are highlighted on Tables 2-1 through 2-17 along with the specific screening criteria that were exceeded. Table 2-18 provides a summary of percent solids results from sludge and soil samples collected from each of the disposal areas. Table 2-19 provides a summary of contaminants detected in each disposal area above project screening criteria. Figures 1-4 through 1-6 provide a visual depiction of test pit and soil boring locations.

2.1.1.1 Sludge/Waste Data Evaluation

This section presents the evaluation of sludge characterization data from each disposal area. The evaluation focuses on contaminants detected in sludge/waste, RCRA characterization analyses of sludge, and air-headspace analysis of sludge samples. The analytical results are summarized on Tables 2-1 through 2-15. Analytical data results are contained in Appendix G.

Area 1

Sludge samples collected from borings advanced in Area 1 contained several VOCs, SVOCs, pesticides, dioxins, and metals above laboratory detection limits. TCLP SVOCs, TCLP metals, and reactive sulfides were also detected in Area 1 sludge. A summary of contaminants detected in sludge samples collected from Area 1 is provided on Tables 2-1 and 2-2.

Contaminants detected in sludge samples at concentrations exceeding screening criteria included 2-butanone, carbon disulfide, 2-methylnaphthalene, 4-methylphenol, pentachlorophenol, 2,3,7,8-TCDD, dioxins as toxicity equivalents (TEQs), antimony, arsenic, chromium, and manganese. Hexavalent chromium was not detected in any of the sludge samples collected from Area 1. A sludge sample collected from SL-104 passed the paint filter test.

The area-composite sludge sample from Area 1 did not exceed TCLP criteria for SVOCs or metals; however, the sample contained reactive sulfides at concentrations that may indicate a potential reactivity concern. There are currently no federal numerical standards to determine exceedance of the RCRA reactivity characteristic. In the absence of a current standard, interim levels contained in a July 1985 guidance, but withdrawn in April 1998 (USEPA, 1998b), were used to identify potential reactivity concerns. Reactive sulfide concentrations in the Area 1 composite sludge sample and its duplicate (694 mg/kg and 663 mg/kg, respectively) were slightly higher than the withdrawn regulatory guidance level of 500 mg/kg.

It was noted that the reactive sulfide concentrations for the Area 1 composite sample and its duplicate were higher than the total sulfide concentrations for the individual Area 1 samples from which the composite sample was taken. These seemingly anomalous results are likely due to the heterogenous distribution of the sulfides within the sludge matrix. Because the sulfides are insoluble, they tend to be unevenly distributed within the solid matrix. As a result there can be significant variability in results from different parts of the same sample or across an area. A more detailed analysis of reactive sulfide versus total sulfide results follows.

The total sulfides result includes the total concentration of acid soluble and acid insoluble sulfides in a sample. The analytical procedure involves adding hydrochloric acid to the sample to liberate the sulfides as hydrogen sulfide gas that is collected in a scrubber. The concentration of total sulfides is expressed in terms of milligrams (mg) hydrogen sulfide generated per kilogram (kg) of sample. The reactive sulfides analysis determines the rate of hydrogen sulfide released from a sample under the specific conditions of the test method. The procedure involves adding sulfuric acid to the sample to liberate the sulfides as hydrogen sulfide gas that is then collected in a scrubber. The concentration of reactive sulfides is also expressed in terms of mg hydrogen sulfide released per kg of sample.

Ideally, for a homogeneous sample, the reactive sulfides result for a sample should not exceed the total sulfides result. However, the less-than-ideal nature of environmental sampling and differences in the two analytical methods explain why in some instances the reactive sulfides results exceed the total sulfides results for the same sample or area. The first factor, and likely the most significant, is sample heterogeneity. Most of the sulfides are present in the solid matrix as insoluble salts. These insoluble sulfides are unevenly distributed within the solid matrix. As a result, two samples collected from the same location may contain significantly different sulfide concentrations. Additionally, since only a fraction of the field sample is used in the laboratory method, even two analyses conducted on different portions of material from the same sample jar could have very different concentrations depending on where the sulfide “granules” were located within the sample.

Another factor that may contribute to the difference in the results is the difference in the two analytical methods. The two methods use different sample mass (50 g for total sulfides, 10 g for reactive sulfide), different acids, and different reaction temperature and time. The difference in sample mass, in particular, may increase the potential for inconsistent results due to heterogeneity issues discussed above. If the sulfides “granules” are unevenly distributed in the sample matrix, the sulfide concentrations in a 10 g and a 50 g sample of the same material could differ considerably solely due to chance. The effect of heterogeneity in the sludge at the site is illustrated by the total sulfides results for sample SL-103 (15.8 UJ) and its duplicate, SL-DUP-06 (230 J). Although the two samples were collected from the same boring, the results are significantly different. These results indicate the possibility for significant differences within the same sample and using the same analytical method. The potential for differences between the Area 1 samples is compounded by the fact that a composite sample from several locations (analyzed for reactive sulfide) is being compared to several individual samples from the area, analyzed by a different method (for total sulfides).

TCLP VOC analysis was not performed on samples from Area 1; however, previous TCLP analyses (GeoSyntec, 2001) did not detect VOCs in excess of RCRA TCLP criteria and the low concentrations of VOCs detected in sludge (Table 2-1) are well below concentrations that could result in exceedance of TCLP VOC criteria.

A headspace air sample collected from boring SL-104 contained several VOCs and sulfur compounds above laboratory detection limits. Concentrations of benzene, carbon disulfide, and methyl mercaptan detected in headspace air samples exceeded screening criteria for headspace air. Headspace results will be used to predict the types and maximum concentrations of odorous sulfides and VOCs likely to be released during excavation of sludge/waste. These results are assumed to represent the concentration of contaminants generated under worst-case, closed conditions (with approximately 1 volume of soil to 2 volumes of air). Concentrations of contaminants in ambient air under actual conditions during excavation would be lower due to dilution of contaminants in a larger volume of air and dispersion of contaminants by air currents. A summary of compounds detected in headspace air samples collected at the site is provided on Table 2-3.

The solids content in sludge samples collected from Area 1 ranged from 13.1 to 35 percent and averaged 25.7 percent solids (Table 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

<u>Area 2</u>

Sludge samples collected from borings advanced in Area 2 contained concentrations of several VOCs, SVOCs, pesticides, dioxins, and metals above laboratory detection limits. TCLP SVOCs and TCLP metals were also detected. A summary of contaminants detected in sludge samples collected from Area 2 is provided on Tables 2-4 and 2-5.

Contaminants detected at concentrations exceeding screening criteria in sludge samples collected from borings SL-201, SL-203, and SL-204 in Area 2 included the following: carbon disulfide, naphthalene, pentachloropheneol, 2,3,7,8-TCDD, dioxins TEQs, antimony, arsenic, and chromium. Sludge samples collected from boring SL-202 exceeded screening criteria for those compounds (except chromium) as well as 4-methylphenol, phenol, aldrin, and heptachlor epoxide. The sludge sample collected from boring SL-205 only exceeded screening criteria for arsenic. Hexavalent chromium was not detected in sludge samples collected from Area 2. A sludge sample collected from boring SL-205 passed the paint filter test.

The area-composite sludge sample from Area 2 did not exceed TCLP criteria for SVOCs or metals and did not contain detectable levels of reactive cyanide or reactive sulfide.

TCLP VOC analysis was not performed on samples from Area 2; however, previous TCLP analyses (GeoSyntec, 2001) did not detect VOCs in excess of RCRA TCLP criteria and the low concentrations of VOCs detected in sludge (Table 2-4) are well below concentrations that could result in exceedence of TCLP VOC criteria.

A headspace air sample collected from boring SL-205 contained detectable concentrations of chlorobenzene, methylene chloride, trichlorofluoromethane, carbon disulfide, and carbonyl sulfide. Detected concentrations did not exceed screening criteria. A summary of compounds detected in headspace air samples collected at the site is provided on Table 2-3.

The solids content of Area 2 sludge samples ranged from 54 to 94.2 percent and averaged 73.3 percent solids (Table 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

Area 3

Sludge samples collected from borings advanced in Area 3 contained detectable concentrations of a few VOCs, a few SVOCs, a few pesticides, Aroclor 1254, and several dioxins. Metals were detected in sludge samples collected from all three borings advanced in Area 3. A summary of contaminants detected in sludge samples collected from Area 3 is contained in Tables 2-6 and 2-7.

Concentrations of naphthalene and pentachlorophenol detected in a sludge sample collected from SL-303 exceeded screening criteria. The concentration of 2,3,7,8-TCDD in a sludge sample collected from SL-301 exceeded the screening criteria of 3.9 ng/kg. The concentrations of arsenic exceeded screening criteria in all three sludge samples. Antimony also exceeded screening criteria in the samples collected from borings SL-301 and SL-303 and chromium exceeded screening criteria in the sample from boring SL-301. Hexavalent chromium was not detected in sludge samples collected from Area 3.

TCLP VOC, TCLP SVOC, and TCLP metals analyses on sludge samples collected from Area 3 revealed very low concentrations of contaminants, none exceeding RCRA TCLP criteria. Reactive cyanide was not detected and reactive sulfide was detected only at low concentrations in one sample.

The solids content of Area 3 sludge samples ranged from 83 to 94 percent and averaged 90.7 percent solids (Table 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

Area 4

Sludge samples collected from borings advanced in Area 4 contained concentrations of VOCs, SVOCs, pesticides, PCBs, dioxins, metals, and reactive sulfide above laboratory detection limits. TCLP VOCs, TCLP SVOCs, and TCLP metals were also detected. A summary of contaminants detected in sludge samples collected from Area 4 is contained in Tables 2-8 and 2-9.

Carbon disulfide and 4-methylphenol were detected at concentrations exceeding screening criteria. Antimony, arsenic, chromium, manganese, and thallium were also detected at concentrations exceeding screening criteria. Hexavalent chromium was not detected in sludge samples collected from Area 4.

A sludge sample collected from boring SL-402 failed the paint filter test, indicating the presence of free liquid in the sample. This result does not seem to be consistent with percent solids values. The sludge sample from Area 4 contained 50 percent solids, which is nearly four times higher than the percent solids content (13.1) of the Area 1 sample that passed the paint filter test (Appendix G). A possible explanation for this result is that the sludge sample from Area 1 has greater water-holding capacity than the sample from Area 4. The paint filter test measures the free liquid that drains from a sample when placed in the test apparatus, not the total amount of water in the material. Therefore, a material with a higher moisture content but greater water-binding capacity (such as clay) may pass the paint filter test while a material with a lower moisture content but less ability to hold water (such as sand) may fail. Additional testing will be required to confirm the presence of free liquids in Area 4 sludge and to determine what actions may be needed to dewater the sludge.

No contaminants were detected in Area 4 sludge samples at concentrations exceeding RCRA hazardous waste criteria.

A headspace air sample collected from boring SL-403 contained detectable concentrations of several VOCs and sulfur compounds. The concentrations of chlorobenzene, toluene, and carbon disulfide exceeded screening criteria established for the assessment of air sampling results. A summary of compounds detected in headspace air samples collected at the site is provided on Table 2-3.

The solids content of Area 4 sludge samples ranged from 36.4 to 79.9 percent and averaged 57.5 percent solids (Table 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

Area 5

Tannery waste material was not identified in Disposal Area 5 through field observations. Thin lenses of possible staining were observed, but obvious visual and olfactory evidence of tannery waste/sludge was not observed in any of the test pits or DPT borings advanced in Area 5. Therefore, the samples from this area consisted of soil from the ground surface to the end of the boring. No overlying or underlying soil samples were collected from these borings. For purposes of chemical analysis the samples were classified as sludge/waste (they were analyzed for the same parameters as other sludge samples). However, because the samples actually consisted of only soil, the results were compared with NH RCMP background soil concentrations as well as the EPA Region IX and NH S-1 screening criteria.

Samples collected from the borings advanced in Area 5 contained one SVOC, one PCB, several dioxins, and several metals above laboratory detection limits. TCLP SVOCs, TCLP metals, and reactive cyanide were also detected. A summary of contaminants detected in samples collected from Area 5 is contained in Tables 2-10 and 2-11.

Only concentrations of antimony and arsenic exceeded screening criteria (the EPA Region IX PRGs). The arsenic concentrations did not exceed NH RCMP background soil concentrations. The antimony concentration in the sample from boring SL-503 exceeded the NH RCMP background soil concentration but did not exceed the NH S-1 screening criteria. A low concentration of hexavalent chromium, below screening criteria, was detected in the sample from boring SL-502. No contaminants were detected in Area 5 samples at concentrations exceeding RCRA hazardous waste criteria.

The solids content of the samples collected from Area 5 ranged from 84.6 to 99 percent and averaged 95.4 percent solids (Tables 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

Area 6

Sludge samples collected from borings advanced in Area 6 contained concentrations of VOCs, SVOCs, pesticides, dioxins, and metals above laboratory detection limits. TCLP VOCs, TCLP SVOCs, TCLP metals, and reactive sulfide were also detected. A summary of contaminants detected in sludge samples collected from Area 6 is contained in Tables 2-12 and 2-13.

Concentrations of 1,2-dichlorobenzene, 1,4-dichlorobenzene, chlorobenzene, naphthalene, pentachlorophenol, 2,3,7,8-TCDD, and dioxins TEQs detected in sludge samples from borings SL-601 and SL-602 exceeded screening criteria. No VOCs, SVOCs, or pesticides/PCBs were detected in SL-603 at concentrations exceeding screening criteria. However, 2,3,7,8-TCDD, antimony, and arsenic were detected in SL-603 at concentrations exceeding criteria. Concentrations of several metals exceeding screening criteria were detected in all three Area 6 borings. Concentrations of antimony, arsenic, barium, chromium, thallium, and vanadium exceeding screening criteria were detected. Hexavalent chromium was not detected in sludge samples collected from Area 6.

No contaminants were detected in Area 6 sludge samples at concentrations exceeding RCRA hazardous waste criteria.

The solids content of sludge samples from Area 6 ranged from 27.3 to 91.3 percent and averaged 51.6 percent solids (Table 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

Area 7

Sludge samples collected from borings advanced in Area 7 contained concentrations of VOCs, SVOCs, pesticides, PCBs, dioxins, and metals above laboratory detection limits. TCLP VOCs, TCLP SVOCs, and TCLP metals were also detected. A summary of contaminants detected in sludge samples collected from Area 7 is contained in Tables 2-14 and 2-15.

Concentrations of 4-methylphenol, benzo(a)pyrene, pentachlorophenol, Aroclor-1242, 2, 3, 7, 8-TCCD, and dioxins TEQs in sludge samples collected from Area 7 exceeded screening criteria. Benzo(a)pyrene and Aroclor-1242 were each only detected at one location. Concentrations of several metals that exceeded screening criteria were detected in sludge samples collected from Area 7 borings, including antimony, arsenic, barium, cadmium, chromium, lead, manganese, mercury, and thallium. Hexavalent chromium was not detected in sludge samples collected from Area 7.

No contaminants were detected in Area 7 sludge samples at concentrations exceeding RCRA hazardous waste criteria.

A headspace air sample collected from boring SL-704 (including a field duplicate sample) contained detectable concentrations of xylenes, toluene, and several sulfur compounds. The concentrations of toluene and methyl mercaptan exceeded project screening criteria established for the assessment of air sampling results. A summary of compounds detected in headspace air samples collected at the site is provided on Table 2-3.

The solids content of sludge samples from Area 7 ranged from 30 to 89.4 percent and averaged 62.1 percent solids (Table 2-18). A detailed tabulation of the solids content in individual samples is provided in Appendix G.

2.1.1.2 Overlying Soil Data Evaluation

This section presents the evaluation of overlying soil data for each disposal area. Composite samples of overlying soil were collected from each disposal area, with the exception of Area 1 (the open lagoon) and Area 5 (where no obvious sludge/tannery waste layer was present). Overlying soils were collected from the ground surface to immediately above the first visually identified tannery sludge/waste layer in each boring. The overlying soil samples from the individual borings within each disposal area were then composited into one area-composite sample for each disposal area. Table 2-16 presents the overlying soils data.

Area 2

The composite sample of overlying soil collected from borings advanced in Area 2 contained three VOCs, two pesticides, several dioxins, and metals above laboratory detection limits (see Table 2-16). Concentrations of 2,3,7,8-TCDD, antimony, arsenic, and chromium exceeded screening criteria. The arsenic concentration did not exceed NH RCMP background soil concentrations. Mercury exceeded NH RCMP background soil concentrations only. Hexavalent chromium was not detected in this soil sample.

Area 3

A composite sample of overlying soil collected from borings advanced in Area 3 contained concentrations of metals and several dioxins above laboratory detection limits (see Table 2-16). The arsenic concentration in this sample exceeded the EPA Region IX screening criterion but did not exceed NH RCMP background soil concentrations. Antimony and chromium exceeded background soil concentrations only. Hexavalent chromium was not detected in this sample.

Area 4

A composite sample of overlying soil collected from soil borings advanced in Area 4 contained concentrations of VOCs, pesticides, PCBs, dioxins, and metals above laboratory detection limits (see Table 2-16). Concentrations of antimony, arsenic, chromium, and manganese exceeded screening criteria. Arsenic and manganese concentrations did not exceed NH RCMP background soil concentrations. Hexavalent chromium was not detected in overlying soil in Area 4.

Area 6

A composite sample of overlying soil collected from borings advanced in Area 6 contained concentrations of chlorobenzene, several dioxins, and several metals above laboratory detection limits (see Table 2-16). The concentration of 2,3,7,8-TCDD exceeded screening criteria, but the dioxins TEQ concentration did not exceed criteria. The arsenic concentration in this sample exceeded the EPA Region IX screening criteria but did not exceed NHDES S-1 or background soil concentrations. The antimony concentration exceeded the EPA Region IX screening criterion and the NH RCMP background soil concentrations. The chromium concentration exceeded the NHDES S-1 and NH RCMP background soil criteria. The concentration of hexavalent chromium detected in overlying soil from Area 6 was slightly below its EPA Region IX PRG (30 mg/kg).

Area 7

A composite sample of overlying soil collected from borings advanced in Area 7 contained concentrations of pesticides, PCBs, several dioxins, and several metals above laboratory detection limits (see Table 2-16). Concentrations of antimony, arsenic, chromium, and mercury exceeded screening criteria. Hexavalent chromium was not detected in samples of overlying soil collected from Area 7.

2.1.1.3 Underlying Soil Data Evaluation

This section presents the evaluation of underlying soil data for each disposal area. Composite samples of underlying soil were collected from each disposal area, with the exception of Area 1 (where refusal was reached before underlying soils were encountered) and Area 5 (where no obvious sludge/tannery waste layer was present). Underlying soils were collected from approximately the 2 feet of soil immediately beneath visually identified tannery sludge/waste in each boring. The underlying soil samples from the individual borings within each disposal area were then composited into one area-composite sample for each disposal area. Table 2-17 presents the underlying soils data.

Area 2

The composite sample of underlying soil collected from borings advanced in Area 2 contained one VOC (chloroform), one SVOC (pentachlorophenol), several dioxins, and several metals above laboratory detection limits (see Table 2-17). Only arsenic was detected at a concentration exceeding screening criteria. The arsenic concentration in this sample also slightly exceeded the NH RCMP background soils concentration. Hexavalent chromium was not detected in this soil sample.

Area 3

A composite sample of underlying soil collected from borings advanced in Area 3 contained concentrations of pentachlorophenol, several dioxins, and several metals above laboratory detection limits (see Table 2-17). The arsenic concentration in this sample exceeded the EPA Region IX screening criterion but did not exceed NH RCMP background soil concentrations. No other analytes exceeded screening criteria. Hexavalent chromium was not detected in this sample.

Area 4

A composite sample of underlying soil collected from borings advanced in Area 4 contained concentrations of 4-methylphenol, several dioxins, and several metals above laboratory detection limits (see Table 2-17). The arsenic concentration in this sample exceeded the EPA Region IX screening criterion but did not exceed NH RCMP background soil concentrations. No other analytes exceeded screening criteria. Hexavalent chromium was not detected in underlying soil in Area 4.

Area 6

A composite sample of underlying soil collected from borings advanced in Area 6 contained concentrations of several dioxins and several metals above laboratory detection limits (see Table 2-17). The arsenic concentration in this sample exceeded the EPA Region IX screening criterion but did not exceed NHDES S-1 or background soil concentrations. The concentration of chromium in this sample exceeded only NH RCMP background soil concentrations. Hexavalent chromium was not detected in underlying soil in Area 6.

Area 7

A composite sample of underlying soil collected from borings advanced in Area 7 contained concentrations of VOCs, SVOCs, dioxins, and metals above laboratory detection limits (see Table 2-17). The concentrations of arsenic and chromium detected in this sample exceeded screening criteria or NH RCMP background soil concentrations. Hexavalent chromium was not detected in underlying soil in Area 7.

2.1.2 Summary of Data Evaluation

This section presents a summary of analytical data for site sludge/waste, overlying soil, and underlying soil.

2.1.2.1 Sludge/Waste

This section presents a summary of the sludge/waste data, focusing on compounds exceeding screening criteria. Table 2-19 presents a summary of compounds exceeding screening criteria in each disposal area.

Sludge/waste samples from all seven disposal areas contained contaminants exceeding project screening criteria. Area 5 samples only exceeded screening concentrations for metals. All other areas exceeded criteria for organic compounds and metals. Areas 1 and 4 also exceeded screening criteria for RCRA disposal analyses. The following text summarizes the exceedences, by analyte group.

VOCs

Four VOCs were detected in site sludge/waste at concentrations exceeding screening criteria. These VOC exceedences occurred in sludge from Areas 1, 2, 4, and 6. Carbon disulfide was the most prevalent, exceeding screening criteria in Areas 1, 2, and 4. The other compounds were detected above screening criteria in one area each: 2-butanone in Area 1; and 1,2-dichlorobenzene, 1,4-dichlorobenzene and chlorobenzene in Area 6.

SVOCs

Three polynuclear aromatic hydrocarbons (PAHs) and three phenols were detected in site sludge/waste at concentrations exceeding screening criteria. These SVOC exceedences occurred in sludge from all disposal areas except Area 5. The most prevalent compounds exceeding screening criteria were pentachlorophenol (Areas 1, 2, 3, 6, 7); 4-methylphenol (Areas 1, 2, 4, 7); and naphthalene (Areas 2, 3, 6). In addition, 2-methylnapthalene, phenol, and benzo(a)pyrene each exceeded criteria in one area (Areas 1, 2, and 7, respectively).

Pesticides/PCBs

Two pesticides and one PCB were detected in site sludge/waste at concentrations exceeding screening criteria. The two pesticide exceedances (aldrin and heptachlor epoxide) occurred in Area 2. The PCB exceedance (Aroclor-1242) occurred in Area 7.

Dioxins

The EPA Region IX PRG for 2,3,7,8-TCDD dioxins is 3.9 ng/kg. This value is used in the screening of contaminants of concern for human health risk assessments. However, current EPA policy recommends the use of 1 ppb (1000 ng/kg) as a cleanup goal for residential settings (USEPA, 1998a). Therefore, to provide a better indication of the extent of dioxins that may have to be addressed in a removal action, the policy-based cleanup goal of 1000 ng/kg was used for screening of dioxin TEQs. The EPA Region IX PRG was used only for screening of the individual dioxin compound 2,3,7,8-TCDD.

The screening criteria for dioxins TEQs was exceeded in sludge/waste samples from Areas 1, 2, 6, and 7. The screening criteria for 2,3,7,8-TCDD was exceeded in Areas 1, 2, 3, 6, and 7.

Metals

Sludge/waste samples from all disposal areas exceeded screening criteria for antimony, arsenic, and chromium (except in Area 5). In addition, manganese concentrations exceeded screening criteria in Areas 1, 4, and 7; thallium exceeded screening criteria in Areas 4, 6, and 7; barium exceeded screening criteria in Areas 6 and 7; vanadium exceeded screening criteria in Area 6; and cadmium, lead, and mercury exceeded screening criteria in Area 7. Hexavalent chromium was not detected at concentrations exceeding screening criteria in any sample from the site.

RCRA Parameters

TCLP criteria for VOCs, SVOCs and metals were not exceeded in any of the sludge/waste samples collected at the site during this or previous site investigations. However, a composite sludge sample and its field duplicate from Area 1 contained reactive sulfides at concentrations that may indicate the potential for classification as a RCRA hazardous waste. There are currently no federal numerical standards to determine exceedance of the RCRA reactivity characteristic. In the absence of a current standard, the interim level (500 mg/kg) contained in a July 1985 guidance withdrawn in April 1998 (USEPA, 1998b), was used to identify potential reactivity concerns. Reactive sulfide concentrations in the Area 1 sludge samples were 694 mg/kg and 663 mg/kg, indicating a potential reactivity concern.

One sludge sample from the site (from Area 4) failed the paint filter test, indicating the presence of free liquids in the sample and the potential need for dewatering or addition of bulking agents prior to final disposal. Additional paint filter testing would be conducted during the characterization of sludge/waste to make a final determination of the need for dewatering measures, but for the purposes of the EE/CA it is assumed that sludge/waste from Area 4 (and possibly from other Areas) may require dewatering prior to transportation and final disposal.

2.1.2.2 Overlying Soil

This section presents a summary of the overlying soil data, focusing on compounds exceeding screening criteria. Table 2-16 presents the overlying soils data.

Composite samples of overlying soil were collected from soil borings in each disposal area, with the exception of Area 1 (the open lagoon) and Area 5 (because no obvious sludge/tannery waste layer was present). No VOCs, SVOCs, pesticides, or PCBs were detected at levels exceeding screening criteria in overlying soil samples.

Relatively low concentrations of dioxins were detected in overlying soil from all disposal areas. Concentrations of 2,3,7,8-TCDD exceeded the Region IX PRG in the samples from Areas 2 and 6, but dioxin TEQ concentrations did not exceed the EPA guidance level of 1000 ng/kg (1 ppb) in any of the overlying soil samples collected from the site.

Several metals were detected in overlying soil samples at concentrations exceeding screening criteria. Concentrations of antimony and arsenic exceeded screening criteria in most samples of overlying soil. However, concentrations of arsenic did not exceed either the NH S-1 or the NH RCMP background soil concentrations. Based on the widespread detection of these metals at similar, relatively low levels in soil throughout the site, and the relatively low screening criteria concentrations, these metals may be attributed to background concentrations present throughout the area.

Concentrations of chromium (a typical tannery contaminant) exceeded NH S-1 screening criteria in overlying soil samples collected from Areas 2 and 4. Chromium concentrations in samples from the other disposal areas exceeded only NH RCMP background soil concentrations. Hexavalent chromium was detected only in the overlying soil sample collected from Area 6, and at a concentration lower than the screening criteria.

Overlying soil samples were collected from various depths depending on observations made during the advancement of sample borings. In Area 2, overlying soil samples were generally collected from the upper 4 feet of soil; in Area 3, samples were generally collected from the upper 2 to 4 feet of soil; in Area 4, from the upper 3 feet of soil; in Area 6, from the upper 5 feet of soil; and in Area 7, from the upper 2 feet of soil.

2.1.2.3 Underlying Soil

This section presents a summary of the underlying soil data, focusing on compounds exceeding screening criteria. Table 2-17 presents the underlying soils data.

Composite samples of underlying soil were collected from borings in each disposal area, with the exception of Area 1 (because refusal was reached before underlying soils were encountered) and Area 5 (because no obvious sludge/tannery waste layer was present). Underlying soils were collected from approximately the 2 feet of soil immediately beneath visually identified tannery sludge/waste in each boring. No VOCs, SVOCs, pesticides, PCBs, or dioxins were detected in underlying soil samples above screening criteria.

Arsenic was detected in all the underlying soil samples exceeding screening criteria. However, concentrations of arsenic were lower than NH S-1 standard and the NH RCMP background soil concentrations in all samples except the one from Area 2, which was slightly higher than the background screening concentration. Based on the widespread detection of arsenic at similar, relatively low levels, and the relatively low screening concentrations, the presence of arsenic may be attributed to background concentrations present throughout the area. Chromium exceeded the NH RCMP background soil concentration in Areas 6 and 7; however it did not exceed the EPA Region IX PRG or NH S-1 criteria for chromium.

2.1.3 Disposal Area Extent and Waste/Soil Volume

Qualitative analysis of test pit logs, observation boring logs, and a historical aerial photograph of the site were used in conjunction with a comparison of laboratory analytical data with screening criteria to estimate the horizontal and vertical extent of tannery waste and overlying soil in each disposal area. This approximation was used to formulate order-of-magnitude volume estimates of tannery sludge/waste and overlying soil that may require removal/treatment consideration in the EE/CA. Sections 2.1.3.1 and 2.1.3.2 present the volume estimation process and results for tannery sludge/waste and overlying soils, respectively. Section 2.1.3.3 explains why volume estimates were not made for underlying soils.

2.1.3.1 Tannery Sludge/Waste

The following sections provide a description of the estimated limits of tannery sludge/waste and preliminary volume estimates for each disposal area. Visual depictions of the estimated horizontal extent of waste are presented on Figures 2-1 through 2-3. A summary of estimated sludge/waste areas, thicknesses, and volumes is presented on Table 2-20.

Area 1

Observations made during advancement of borings in Area 1 indicate that the thickness of sludge in the lagoon is at least 10 to 12 feet. Manual borings advanced in this area reached refusal (probable till or bedrock) at depths of 10 to 12 feet, with no underlying soils recovered. In evaluating methods to estimate the depth of sludge in Area 1, nearby borings in Area 2 (former site of a second open lagoon) and information on depth to till and/or bedrock in nearby borings and monitoring wells were evaluated. It was determined that since reported bedrock depths in the immediate area vary considerably, it would be difficult to accurately project bedrock depths underlying Area 1, and to use this projected depth to estimate the bottom of sludge.

Therefore, in order to provide an estimated maximum sludge thickness in Area 1, it was assumed that the bottom elevations of the two lagoons (Areas 1 and 2) may have been similar, and the estimated bottom elevations of sludge in Area 2 borings were used to estimate the depth of sludge in the Area 1 lagoon. Borings advanced in Area 2 encountered underlying soil or bedrock at approximately 16 to 19 feet below ground surface (bgs) (elevation 109 to 113 feet above mean sea level [MSL]). Instrument survey data and field observations of water depth indicate that the elevation of the top of sludge in the Area 1 lagoon is approximately 128 feet above MSL (Figure 2-1). Based on this information, it is estimated that the average sludge thickness in Area 1 is approximately 17 feet.

The lateral extent of Area 1 sludge/waste was estimated based on field observations, boring logs, and a historical aerial photograph of the site taken while the facility was in operation (see photo in Appendix H, date unknown). The aerial photograph shows the footprint of the Area 1 lagoon to be considerably larger than the current footprint. The photo indicates that the lagoon extended farther east into the western side of Area 3. Borings and test pits in Area 3 confirm that sludge is present beneath the current eastern berm of Area 1 and indicate that the top of sludge beneath the berm is at approximately the same elevation as the top of sludge in Area 1. Based on these observations, it is assumed that the areal extent of sludge in Area 1 includes the sludge beneath the current eastern berm. The lateral extent of Area 1, including the westernmost portion of Area 3 (see Figure 2-1), is estimated to be 40,000 square feet (SF). Assuming an average sludge thickness of 17 feet, it is estimated that a volume of approximately 680,000 cubic feet (CF) of sludge is present in Area 1.

Area 2

The lateral extent of Area 2 sludge/waste was estimated based on boring and test pit logs and a historical aerial photograph of the site (Appendix H). The south and east limits of sludge in Area 2 were approximated using observations recorded during the excavation of TP-2-03, TP-2-12, TP-2-14, and TP-2-15, which indicated that tannery sludge was not present in these areas. The northeastern and western limits of Area 2 were estimated based on the aerial photograph and test pit and boring observations. The areal extent of sludge/waste in Area 2 is estimated to be 80,000 SF.

Test pit and boring logs indicate that sludge/waste thicknesses in Area 2 generally range from 6 to 13 feet. It is estimated that the average thickness of sludge in Area 2 is 10 feet. Based on these estimates, the estimated volume of sludge/waste in Area 2 is 800,000 CF.

Area 3

The lateral extent of Area 3 was estimated based on boring and test pit logs and a historical aerial photograph of the site (Appendix H). Field observations made during the excavation of test pits and advancement of observation borings in Area 3 delineated the approximate southern, northern, and eastern limits of sludge/waste. Test pits and soil borings advanced in the western part of Area 3 confirm that sludge/waste is present beneath the berm separating Area 3 from the Area 1 lagoon and the top of sludge beneath the berm is at approximately the same elevation as the top of sludge in Area 1. These observations and the historical aerial photo indicate that the sludge present beneath the berm is a continuation of the sludge in Area 1. Therefore the sludge/waste volume estimated for Area 3 excludes the sludge beneath the berm.

Based on these observations, the areal extent of sludge/waste in Area 3 is estimated to be 2,000 SF. Boring and test pit logs indicate that sludge/waste thicknesses in Area 3 range from 1 to 6 feet. Based on an assumed average thickness of 5 feet, it is estimated that 10,000 CF of sludge/waste is present in Area 3.

Area 4

Observations made during the excavation of test pits delineated the approximate limits of sludge in Area 4. The southern and western limits were delineated by test pits TP-4-1, TP-4-2, TP-4-5, TP-4-6, and TP-4-7. The horizontal extent of sludge is assumed to approach the base of the slope to the north and east of Area 4. The estimated areal extent of sludge in Area 4 is 3,000 SF.

Boring and test pit logs indicate that sludge/waste thicknesses in Area 4 range from approximately 5 to 9 feet. Based on an assumed average thickness of 9 feet, it is estimated that 27,000 CF of sludge is present in Area 4.

Area 5

No visual or olfactory evidence of tannery sludge was observed during the excavation of test pits or advancement of borings in Area 5. Possible indications of waste—consisting of black streaks, lenses of dark sand, and potentially stained soil—were observed within a matrix of poorly-graded fine sand.

Analytical data from samples collected from borings advanced in Area 5 reveal that only concentrations of antimony and arsenic exceeded screening criteria. Several contaminants that were typically detected in sludge samples at the site (sulfides, phenols, and PAHs) were not present above detection limits in Area 5 samples.

Although antimony and arsenic were detected in Area 5 at concentrations above screening criteria, the concentrations found were below the preliminary remediation goals developed for the site and discussed further in Section 3.3. As a result of the lack of visual and chemical confirmation of sludge/waste, no waste volume was included for Area 5.

Area 6

Observations made during the excavation of test pits and advancement of borings revealed that obvious evidence of tannery sludge is present at TP-6-03, TP-6-04, TP-6-05, TP-6-06, SL-601, and SL-602. Most other test pits and borings in Area 6 contained fill and/or waste layers consisting of small clusters of hair and hide, but no obvious sludge. Test pits TP-6-02 and TP-6-10 did not contain evidence of tannery waste. The estimated areal extent of sludge in Area 6 is 3,500 SF.

Boring and test pit logs indicate that sludge/waste thicknesses in Area 6 generally range from 4 to 7 feet. Based on an assumed average thickness of 5 feet, it is estimated that 17,500 CF of sludge/waste is present in Area 6.

Area 7

Observations made during the excavation of test pits and advancement of borings in Area 7 delineated the approximate northern and southern limits of sludge/waste. The eastern limit of the sludge/waste is assumed to approach the concrete retaining wall and base of hill southwest of the main facility building. The western limit of the sludge/waste is assumed to approach the top of the slope at the edge of Area 7. The areal extent of sludge/waste in Area 7 is estimated to be 8,000 SF.

Observations during test pit and soil boring advancement indicate that the presence and appearance of sludge/waste in Area 7 is not uniform across the area and is different than that observed in other areas. Observed wastes included scraps of hide, clumps of hair, black sludge, purple-black sludge, and purple cellulose-like material. At some borings sludge was present; however, many borings and test pits contained only miscellaneous waste and fill materials.

Boring and test pit logs indicate that sludge/waste thicknesses in Area 7 generally range from 5 to 13 feet. Based on an assumed thickness of 12 feet, it is estimated that 96,000 CF of sludge/waste is present in Area 7.

2.1.3.2 Overlying Soils

As presented in Section 2.1.2.2, overlying soils only exceeded screening criteria for metals. The organic compounds typical of sludge/wastes across the site were detected in overlying soils only sporadically, and at concentrations below screening criteria. Overlying soils exceeded screening criteria for antimony, arsenic, and chromium. With the exception of chromium, the presence of these metals may be attributed to background conditions. Although several metals were present at concentrations above screening criteria, the concentrations were below the preliminary remediation goals developed for the site and discussed further in Section 3.3. As a result of the lack of visual and chemical confirmation of sludge/waste, no waste volume was included for the overlying soil.

Regardless of whether the overlying soil will have to be addressed as waste, it would have to be removed to access the underlying sludge/waste. If the soil does not require removal and treatment or disposal as waste, it would be desirable to segregate the overlying soil from the sludge/waste during excavation to avoid the costs of disposing or treating these soils along with the sludge/waste. Therefore, the volume of overlying soil that could be practically segregated from the sludge/waste during excavation was estimated. Due to the limitations of standard excavation equipment, it was assumed that 1 foot of soil should remain as a buffer above the sludge/waste to ensure that the sludge/waste is not excavated and mixed into the overlying soils. Additionally, it was assumed that it was not practical to segregate overlying soils that were less than 2 feet thick.

To estimate the volume of overlying soil that could be practically segregated during excavation, the test pit and boring logs for each disposal area were evaluated and the average overlying soil thicknesses were estimated for each area. A 1-foot thickness was then subtracted from the averages to estimate the practical thickness for segregation. These thicknesses were then multiplied by the estimated area of sludge/waste in each disposal area, discussed above in Section 2.1.3.1. The following bullets summarize the overlying soil thickness evaluation.

- The thickness of overlying soils in Area 2 ranged from 3 to 6 feet and averaged approximately 4 feet. The practical thickness for segregation was therefore assumed to be 3 feet.

- The thickness of overlying soils in Area 3 ranged from 2 to 7 feet and averaged approximately 3 feet. The practical thickness for segregation was assumed to be 2 feet.

- The thickness of overlying soils in Area 4 ranged from 1 to 5 feet and averaged approximately 3 feet. The practical thickness for segregation was assumed to be 2 feet.

- The thickness of overlying soils in Area 6 ranged from 0 to 6 feet and averaged approximately 3 feet. The practical thickness for segregation was assumed to be 2 feet.

- The thickness of overlying soils in Area 7 ranged from 0 to 5 feet; however, in most locations the thickness was less than 2 feet. Because of the limitations of standard excavation equipment, it was concluded that it would not be practical to segregate the thin and discontinuous layer of overlying soils in this area.

Based on these thicknesses and the areas discussed in Section 2.1.3.1, the total volume of overlying soil at the site that can be practically segregated during excavation is estimated to be approximately 9,500 cubic yards. The results of the evaluation are presented on Table 2-20.

2.1.3.3 Underlying Soils

As presented in Section 2.1.2.3, underlying soils only exceeded screening criteria for arsenic, which may be present due to background conditions. The organic compounds typical of sludge/wastes across the site were detected in underlying soils only sporadically, and at concentrations below screening criteria. Additionally, the underlying soils are typically present at depths greater than 10 feet bgs, and therefore are not likely to be accessible for human exposure. As a result, these soils will likely not warrant treatment as waste during an NTCRA.

Because the underlying soils are unlikely to be considered as waste to be addressed during the NTCRA and they would not require excavation to access the sludge/waste present, no waste-soil volumes were estimated for the underlying soils.

2.1.4 Wetland Delineation

The wetland delineation performed at the site used the three parameter approach based on vegetation, soils, and hydrology described in the Corps of Engineers Wetlands Delineation Manual (COE Manual, Environmental Laboratory, 1987). This section presents the general approach and results of the wetland delineation survey.

2.1.4.1 Wetland Delineation Background

Except for certain "problem area" situations and other specific exceptions identified in the COE Manual, any area delineated as a wetland according to the COE Manual must display positive evidence of three characteristics:

- Hydrophytic vegetation
- Hydric soils
- Wetland hydrology

Hydrophytic Vegetation

Hydrophytic vegetation is defined in the COE Manual as the sum total of macrophytic plant life growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content. Most common plant species in the United States have been assigned an indicator status based on empirical observation of their relative occurrence in wetlands and uplands. These include:

OBL (Obligate Wetland)	Plant species that occur almost always (estimated probability greater than 99 percent) in wetlands under natural conditions; however they may occur rarely (estimated probability less than 1 percent) in nonwetlands.
FACW (Facultative Wetland)	Plant species that occur usually (estimated probability 67 to 99 percent) in wetlands, but also occur (estimated probability 1 to 33 percent) in nonwetlands.
FAC (Facultative)	Plant species with a similar likelihood (estimated probability 33 to 67 percent) of occurring in both wetlands and nonwetlands.
FACU (Facultative Upland)	Plant species that occur sometimes (estimated probability 1 to 33 percent) in wetlands, but occur more often (estimated probability 67 to 99 percent) in nonwetlands.
UPL (Upland)	Plant species that occur rarely (estimated probability less than 1 percent) in wetlands, but occur almost always (estimated probability greater than 99 percent) in nonwetlands under natural conditions.

For some plant species, the indicator status is modified by adding a "+" or "-". A "+" means that the plant species is slightly more likely to occur in wetlands than suggested by its indicator status alone. A "-" means that the plant species is slightly less likely to occur in wetlands than suggested by its indicator status alone.

To document that an area supports hydrophytic vegetation according to the COE Manual, more than 50 percent of the dominant plant species in each vegetational stratum must have an indicator status of OBL, FACW or FAC (excluding FAC-). The COE Manual suggests the use of four strata: trees, saplings and shrubs, herbs, and woody vines. However, the COE has approved the use of a 5-stratum approach developed in another wetland delineation manual (FICWD, 1989). Under this alternative approach, used for the Mohawk Tannery site, the following five strata are recognized:

Trees	Woody plants greater than 5 inches in diameter at chest height.
Saplings	Woody plants less than 5 inches in diameter at chest height and greater than 20 feet in height.
Shrubs	Woody plants greater than 3 feet in height and less than 20 feet in height.
Herbs	Plants less than 3 feet in height.
Woody Vines	Woody vines climbing on trees in a forested area.

Vegetation in wetlands may display one or more morphological adaptations that assist in survival under saturated soil conditions. The COE Manual lists several such morphological adaptations, including buttressed (swollen) tree trunks, unusually shallow root systems, adventitious roots, and others. The hydrophytic vegetation parameter may be met if two or more dominant species display one or more of these adaptations, even if the vegetation is composed primarily of FACU or UPL species.

<u>Hydric Soils</u>

Hydric soil is defined in the COE Manual as soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. The National Technical Committee for Hydric Soils (NTCHS) has developed a list of soil series (soils having similar profile characteristics) that meet the definition of hydric soil (NTCHS, 1991). If soil profile data collected in a specific area can be matched to a recognized soil series, then its status as hydric can be determined by checking the NTCHS list.

Otherwise, a determination can be made based on the presence of one or more field indicators of hydric soil listed in the COE Manual. The most readily observable indicator is soil color. Soil colors are expressed in terms of hue, value, and chroma using a Munsell Soil Color Chart. Typically, soil colors with a chroma of 1 (regardless of hue and value) are indicative of hydric soils. Soils with a chroma of 2 that are also mottled (spotted) are generally hydric as well. Other readily observable indicators of hydric soils include a predominantly organic soil profile (histosols or mineral soils with histic epipedons), sulfidic material (rotten egg smell), or iron and manganese concretions (black or dark brown specks).

The New England Division of the US Army Corps of Engineers recognizes a number of additional field indicators of hydric soils specific to the New England region, which includes New Hampshire (NEIWPCC, 1998). These regional field indicators of hydric soil were considered as part of the wetland delineation of the Mohawk Tannery site wetlands.

Wetland Hydrology

Wetland hydrology is defined in the COE Manual as the sum total of wetness characteristics in areas that are inundated or have saturated soils for a sufficient duration to support hydrophytic vegetation. Areas generally must be inundated or saturated for at least 5 percent of the growing season (in some cases 12.5 percent) during typical rainfall years for wetland hydrology, as defined in the COE Manual, to be present. The presence of wetland hydrology is usually determined through direct or indirect evidence of seasonal saturation or inundation. The COE Manual lists several other indicators of wetland hydrology that indirectly suggest that an area has wetland hydrology even though it may be dry at the time of observation. These include the presence of:

Watermarks	Lines on trees or other upright structures that represent the maximum static water level reached during an inundation event.
Drift Lines	Accumulations of debris along a contour that represents the height of an inundation event.
Sediment Deposits	Thin layers of mud or fine debris coating vegetation or the soil surface.
Drainage Patterns	Deposited debris or scoured leaf litter indicative of water flow patterns.

Other indicators of wetland hydrology are commonly recognized by wetland scientists even though they are not formally stated in the COE Manual. These include blackened leaf litter on the soil surface and the presence of oxidized rhizospheres (thin rust colored soil zones surrounding living plant roots). Although the presence of these indicators cannot be used as the sole basis for determining wetland hydrology, their presence can be noted as supplementary supporting information.

Field indicators of wetland hydrology, especially observation of inundation or saturation, must be viewed in the context of recent rainfall occurrences and seasonal water table fluctuations. For example, the presence of saturation during a seasonally wet time period or immediately following heavy rainfall cannot be used to conclude that wetland hydrology is present, and the absence of saturation during a seasonally dry period or following a drought cannot be used to conclude that wetland hydrology is absent.

2.1.4.2 Field Protocol

Preliminary reconnaissance of the Mohawk Tannery site revealed that the on-site wetlands cover less than 5 acres. Therefore, representative locations were selected on the upland and wetland sides of the suspected wetland boundary (in perpendicular transects) to confirm its accuracy, as outlined in Part IV, Section D, Subsection 2 of the COE Manual.

Observations at each selected representative location were documented using a data form developed by the New England Division of the US Army Corps of Engineers (Appendix I). Dominant plant species were recorded for lands surrounding each location (roughly a 30-foot radius circle, but not crossing the wetland boundary), together with their Indicator Status for Region I (which includes New Hampshire) according to Reed, 1988. Then a hole was dug with a soil auger and the soil profile (including the different textures, colors, and consistencies of the soil and the depths at which they occurred) were noted to a depth of approximately 15 to 20 inches (or auger refusal due to compacted or highly saturated soils). Any hydrologic indicators present in the area were noted.

The wetland/upland boundary was traversed and flagged with surveyor's flagging. The coordinates of each boundary flag were surveyed to submeter accuracy by using Global Positioning System (GPS) equipment (Trimble Navigation Pathfinder ProXR). The GPS results were used to create a wetland delineation drawing at a scale of 1 inch equals 60 feet (Figure 1-3, map pocket).

2.1.4.3 Wetland Delineation Results

The site consists of two contiguous properties: an approximately 15-acre developed parcel to the north and an approximately 15-acre undeveloped parcel to the south.

Northern Parcel

Background information and a site walkover indicated that any wetlands that may have been present in the developed area of the site would have been significantly disturbed during the tannery's operations. It could not be determined if "natural" wetlands were present prior to site disturbances from tannery operations. Most of the developed area along the Nashua River had been excavated to form settling ponds for tannery waste operations.

The Area 1 lagoon (Figure 1-3) was constructed in the 1960s and remains open, but has not been used or maintained as a settling pond since the Mohawk Tannery ceased operations in 1984. The lagoon is approximately 60 feet from the Nashua River at its closest point. Due to the standing water and vegetation present, the Area 1 lagoon was evaluated to determine whether it would be considered a jurisdictional wetland. After consultation with the COE and NHDES, it was determined that the lagoon is not considered a wetland, based primarily on the fact that the lagoon was part of a permitted treatment unit under the clean water act. (Field data forms and additional documentation [COE, 2002; NHDES, 2002] of the non-wetland determination for Area 1 are presented in Appendix I.)

Disposal Area 2 (the former lagoon that has been covered with soil fill) was evaluated and determined not to be a jurisdictional wetland. Several observation plots conducted in the area confirmed this conclusion, even though FACW vegetation (*Phragmites communis*) is present. Phragmites often colonize disturbed non-wetland areas. Hydric soils and wetland hydrology criteria were not met in Area 2. An approximate average of 4 feet of fill material has been placed over tannery sludge wastes in this area. A field data form for an example plot completed in Area 2 (Area 2 X (1-3)) and a figure showing observation plot locations are presented in Appendix I; .

Southern Parcel

Two wetland areas were delineated in the southern undeveloped parcel of land at the site. These wetlands are shown as Wetlands A and B on Figure 1-3. These wetlands were formed in alluvial deposits in slightly concave areas of the floodplains bordering the Nashua River. Wetland A was disturbed during the installation of a sewer line in the 1970s. These activities may have isolated Wetland B from a more extensive wetland system located to the southeast of this parcel. Field Data Forms and a figure showing wetland transect locations are presented in Appendix I.

2.1.5 Endangered/Threatened Species Evaluation

The United States Fish and Wildlife Service (FWS) and State of New Hampshire Department of Resources and Economic Development (Division of Forests and Lands) were contacted for the endangered/threatened species evaluation conducted for the site. The FWS did not identify any recorded occurrences of threatened or endangered species in the immediate vicinity of the site, with the exception of "occasional transient bald eagles". The FWS indicated that a biological assessment or any other further action under Section 7 of the Endangered Species Act would not be necessary, but the determination may be reconsidered if additional information were to become available (FWS, 2002).

The State of New Hampshire Division of Forests and Lands performed a search of the Natural Heritage Inventory (NHI) database and did not identify any recorded occurrences of sensitive species or natural communities in the immediate vicinity of the site. NHI noted, however, that since many areas of the state have not been surveyed, a negative result should not be interpreted as proof that no sensitive species are present (NHI, 2001).

2.1.6 Water Table Measurements and Inventory of Existing Wells

The table below provides a summary of monitoring well elevations and groundwater measurements collected during the topographic survey and existing well inventory, respectively (well locations are shown on Figure 1-3).

GROUNDWATER ELEVATION SUMMARY, OCTOBER 2001			
Monitoring Well Number	Elevation of Top of PVC Casing (feet above MSL)	Groundwater Depth[1] (feet below PVC)	Groundwater Elevation[2] (feet above MSL)
MW-GZ-1	190.41	69.61	120.80
MW-GZ-4	128.35	12.36	115.99
MW-GZ-6	130.90	14.20	116.70
MW-GZ-9	130.89	14.35	116.54
MW-GZ-10	125.57	7.75	117.82
MW-GZ-11	125.09	7.62	117.47

1. Groundwater depths measured from top of PVC casing
2. Elevations referenced to North American Vertical Datum (NAVD) 1988.
   MSL = Mean Sea Level PVC = Polyvinyl Chloride

Water table elevations, ground elevations, and sludge depths observed in site borings were used to estimate the volume of tannery sludge that is located below the water table. This information will be considered during the evaluation of excavation as an alternative for sludge removal. The evaluation indicates that sludge is currently located beneath the water table only in Areas 1 and 2. In these areas the groundwater elevation was estimated to range between 117 and 118 feet above MSL at the time of the monitoring well survey in October 2001. The estimated elevation of the bottom of sludge in Area 1 is 112 feet and the estimated elevation of the bottom of sludge in Area 2 ranges from 109 to 118 feet MSL. Therefore, based on October 2001 conditions, as much as 6 feet of sludge is estimated to be submerged in Area 1 and up to 9 feet of sludge in Area 2.

As the water table rises, additional (shallower) sludge in these areas, as well as sludge in other areas (particularly Area 3, where the bottom of sludge is estimated to be approximately 118 feet

MSL) will become submerged. The October 2001 conditions are believed to represent approximate seasonal low groundwater conditions.

2.1.7 Topographic/Land Surveying

As discussed in section 1.4.8, a topographic/land survey was conducted to verify the locations of important site features, spot-check the topographic contours, and identify selected sampling locations. The surveyed features are presented on Figure 1-2 and subsequent site figures. The results of the survey were compared with the base map provided by the City of Nashua, to verify site features and elevations. In general, the base map correlates well with the surveyed points. There are minor differences in elevation at some individual points, but overall the features and topographic contours on the base map appear to be a reasonable depiction of the features and topography of the site.

2.2 Site Geology, Hydrogeology, and Hydrology

This section presents a general characterization of site geology, hydrogeology, and hydrology.

2.2.1 Site Geology and Hydrogeology

This section presents a general description of the geologic and hydrogeologic features of the site. The discussion presented here is based on data and interpretations presented by GZA in their 1985 hydrogeological study and on data collected by TtNUS during field investigations performed in 2001.

Bedrock

Bedrock at the site is mapped as part of the Merrimack group of Silurian and Ordovician age, locally referred to as Merrimack schist (Billings, 1966). Observations made from bedrock cores collected at the site revealed it to be moderately to slightly weathered and moderately to highly fractured. GZA provided an interpretation of bedrock topography based on test borings and test pits performed in 1985. Bedrock elevations at the site were generally observed to decrease in a southerly direction along a ridge spanning from Area 4 to south of Area 2 (GZA, 1985).

In reference to ground surface, bedrock was encountered at approximately 8 feet bgs in test boring GZ-4, approximately 30 feet bgs in test boring GZ-6, approximately 40 feet bgs in test boring GZ-7, approximately 31 feet bgs in test boring GZ-9, and at approximately 37 feet bgs in test boring GZ-12 (refer to Figure 1-3 for boring/well locations) (GZA, 1985). TtNUS encountered bedrock in Area 2 at approximately 18 feet bgs during advancement of boring SL-201 and at approximately 22 feet bgs during advancement of boring SL-203 (TtNUS, 2002).

Overburden Geology

Three major types of natural overburden deposits are present at the site—lacustrine delta deposits, glacial till, and alluvial terrace deposits. Present soil conditions result primarily from the modification of topography by glacial action and river erosion and subsequent deposition. Site development activities, including the excavation of soil and placement of fill comprised of tannery wastes or granular soil, have altered surface and subsurface conditions throughout the site (GZA, 1985).

Most of the thickness of overburden material at the site consists of Pleistocene epoch stratified, sandy, lacustrine delta deposits. The thickness of this deposit ranges from 0 feet (absent) near the Nashua River to approximately 80 feet at GZ-1 on the east border of the site. Lacustrine delta deposits generally consisted of medium dense, silty fine sand and fine to medium sand.

Boring logs compiled by GZA in 1985 indicate that till was generally encountered directly above bedrock in the western portion of the site along the Nashua River (Areas 1 and 2). Observed thickness of till was between 1 and 13 feet.

Alluvial deposits of the Holocene epoch were observed overlying glacial till, delta deposits, or bedrock along the western portion of the site. Alluvial deposits generally consisted of stratified, fine to medium sand with varying amounts of silt. Alluvial deposits were encountered primarily below the groundwater table.

Hydrogeology

As discussed in Section 2.1.6, groundwater depths ranged between 7 and 14 feet bgs in monitoring wells located in the vicinity of Areas 1 and 2, and approximately 70 feet bgs in the eastern portion of the site adjacent to Warsaw Avenue during the TtNUS field investigation in September 2001 (TtNUS, 2002). GZA collected groundwater depth measurements subsequent to the installation of monitoring wells in 1985 and observed similar depths to groundwater. GZA inferred from groundwater elevations that the direction of groundwater flow on the site was generally towards the west or southwest (GZA, 1985). Groundwater level measurements collected by TtNUS generally supported this conclusion.

GZA estimated the hydraulic conductivity of subsurface material at the site using in-situ field testing methods. Hydraulic conductivity was estimated by evacuating water from, or introducing water into, a well and monitoring the rate at which groundwater levels returned to their original level. Using this conductivity data, hydraulic gradients estimated from groundwater level measurements, and an estimate of soil porosity, GZA estimated the groundwater flow velocity through overburden material to be between 1 and 125 feet/year (GZA, 1985).

Groundwater beneath the site is not used as drinking water. According to the EPA Approval Memorandum (Appendix A), residents in the vicinity of the site are supplied with municipal water by the Pennichuck Water Company. The majority of residents within 4 miles of the site obtain their drinking water from municipal water supplies located greater than 4 miles from the site. Two residential wells approximately 30 feet deep are reported to be located approximately one half mile southeast of the site. These wells were sampled by NHDES for volatile organic compounds and metals in October 1994. No evidence of contamination related to the site was identified.

2.2.2 Floodplain

The 100-year flood elevation of the Nashua River in the area of the site was determined to be 131.7 feet MSL based on the National Geodetic Vertical Datum (NGVD) 1929. This flood elevation was determined based on Flood Insurance Rate Map panel number 5 of 10, community panel number 330097-0005B, with an effective date of June 15, 1979. This elevation was converted to North American Vertical Datum (NAVD) 1988 for consistency with the site base map. The 100-year flood elevation in the vicinity of the site was determined to be 131 feet MSL based on NAVD 1988.

Topographic surveying conducted in October 2001 confirmed that the majority of Area 2 and most of the southern parcel is located within the 100-year floodplain of the Nashua River (Figure 1-3). The Area 1 Lagoon was determined not to be within the 100-year floodplain due to the elevation of the berm that has been constructed around its perimeter. The top elevation of the berm is approximately 136.5 feet MSL. If the berm was ever breached during a major flood event, then the contents of the lagoon, which are located below the 100-year flood elevation (at approximately 130 feet MSL), could be affected.

2.2.3 Nashua River

The Nashua River flows from north to south along the western border of the site. Two dams in the vicinity of the site, the Mines Falls Dam upstream and Jackson Falls Dam downstream, control the stream discharge past the site (GZA, 1985b). The confluence of the Nashua and Merrimack Rivers is located approximately 3.5 miles downstream of the site. Both rivers are contiguous to wetlands and are characterized as fisheries.

2.3 Contaminant Fate and Transport

As described in Section 2.1, a variety of contaminants including VOCs, SVOCs, pesticides, PCBs, dioxins, and metals were detected in tannery sludge/waste in all disposal areas except Area 5, where no evidence of sludge was detected. Additionally, relatively low concentrations of dioxins and metals were detected in surface soils in Areas 2 through 7. This section describes the major mechanisms of contaminant transport in environmental media at the site.

Potential Migration of Contaminated Sludge in Areas 1 and 2 in Event of Flooding

Most of Area 2 is situated within the 100-year floodplain of the Nashua River. In the event of a flood, the area would be submerged under flood waters and the cover soils may be eroded exposing highly contaminated sludge to the flood waters. Contaminants in the soils and sludge would be subject to erosion and transport into the Nashua River. Contaminants would likely deposit in the river sediments near the site or be transported further downstream.

The Area 1 Lagoon was determined not to be within the 100-year floodplain because the berm around its perimeter is higher than the 100-year flood elevation. However, if the berm was ever breached, then the contents of the lagoon would be subject to erosion and transport into the Nashua River during a major flood event.

Migration of Contaminants in Surface Soils by Erosion

Contaminants located at the surface of Areas 3 through 7 are subject to erosion through precipitation and surface runoff. Areas 3 through 7 are situated on a hillside, that slopes down to the floodplain of the Nashua River. Areas 1 and 2 and a wetland (at the border of the northern and southern parcels of the site) are situated on the nearly level land at the bottom of the hillside. Contaminants in surficial materials in Areas 3 through 7 may migrate through precipitation runoff overland to the floodplain and wetland, and ultimately to the river.

Contaminant Leaching to Groundwater

The results of groundwater sampling conducted by NHDES in May of 2001 indicate the presence of several contaminants in groundwater that were also detected in the tannery sludge/waste. Because the sludge/waste at the site is subjected to precipitation and portions are buried beneath the water table, organic chemicals and metals are likely being leached from the waste/sludge into the underlying groundwater. Although there is limited information regarding the hydrogeology of the site, groundwater is interpreted to flow generally west or southwest across the site and discharge to the Nashua River. Therefore, contaminants that leach from the sludge/waste may ultimately discharge to the Nashua River through the groundwater.

2.4 Streamlined Human Health Risk Evaluation

A streamlined human health risk evaluation was performed to identify the risk to humans from soil and sludge at the site. The assessment is focused on the soil and sludge to support selection of removal actions under the NTCRA. The purpose of a streamlined risk evaluation is to evaluate the exposure scenarios associated with the media of concern that could pose the greatest potential risks. Other media (surface water, groundwater, air, etc.) that may have been impacted by past operations and waste disposal practices at the tannery will be evaluated during the remedial investigation of the site. A full Human Health Risk Assessment, which is typically performed as a part of a remedial investigation, would evaluate risk to all receptors interacting with all site media. Section 2.4.1 provides an overview of the site. Section 2.4.2 contains a discussion of the selection of contaminants of potential concern (COPCs) and exposure point concentrations (EPCs). Section 2.4.3 contains information on the potential receptors considered and the routes by which they might be exposed. Section 2.4.4 contains a discussion of toxicity factors used and the potential adverse effects of site contaminants. Section 2.4.5 contains the numerical results of the risk characterization. Finally, Section 2.4.6 presents uncertainties associated with this risk evaluation.

2.4.1 Overview of the Exposure Areas

The site encompasses seven disposal areas within the developed portion of the formerly industrial site. Around the time of the tannery's closure the property was re-zoned as residential to help facilitate future development of the site. A detailed description of the site is provided in Section 1.2 of this EE/CA. A characterization of the contamination detected within the disposal areas at the site is discussed in Section 2.1.

Table 2-21 presents the potential exposure points included in this human health risk evaluation and the receptors and exposure pathways considered. The two most likely risk receptor populations for the site based on its current abandoned condition and potential future development are adolescent trespassers and residents. These groups were evaluated for exposure to soil and sludge from on-site disposal areas. Three different exposure areas were defined based on physical features of the site, the data available from disposal areas, and the persons expected to access them. These exposure areas included surface sludge from Area 1 (an open lagoon), surface soil and sludge from Areas 2 through 7, and soil and sludge from 0 to 10 feet below ground surface (bgs) from Areas 1 through 7.

2.4.2 Data Evaluation

Data evaluation is an exposure area-specific task that uses a variety of information to determine which of the detected chemicals in a dataset are most likely to present a risk to potential receptors. The end result of this qualitative selection process is a list of contaminants of potential concern (COPCs) and representative exposure point concentrations for each dataset.

2.4.2.1 Selection of Contaminants of Potential Concern

Tables 2-22.1 through 2-22.3 present summaries of the COPC selection process for quantitative risk evaluation for Area 1 surface sludge, Areas 2 through 7 surface soil and sludge, and Areas 1 through 7 soil and sludge from depths of 0 to 10 feet bgs, respectively. All validated analytical data collected during the EE/CA field investigation were used to identify COPCs. Site data were divided into three datasets based on the identified exposure areas and scenarios. The datasets are described in the following bullets. Appendix J presents listings of sample locations included in each dataset.

- The Surface Sludge Area 1 dataset represents samples taken from the surface of the sludge in the open lagoon down to a depth of 10 to 12 feet bgs (where refusal was encountered). All samples in this dataset are composite samples extending from the surface of the lagoon to the bottom of the sludge recovered in an individual boring.

- The Surface Soil and Sludge Areas 2 through 7 dataset includes all soil and sludge samples from these areas which originate at the surface of the disposal area. The samples in this dataset represent the range of conditions found in Areas 2 through 7, including area-composite samples of a distinct soil fill layer above the sludge, such as that found in the overlying soil composite samples from Areas 2, 3, 4, 6, and 7; composite samples of soil, sludge, and debris all intermixed as found in samples from two borings in Areas 6 and 7; and composite samples of soil beginning at the surface and extending deeper than 12 feet bgs from borings in Area 5, where no visible or chemical evidence of sludge/waste was found. Most samples in this dataset are composite samples that extend below 2 feet bgs with one sample extending to 20 feet bgs.
- The All Soil and Sludge Areas 1 through 7 (“all soil”) dataset is the most inclusive. This dataset includes all samples obtained from Areas 1 through 7 that begin at a depth between 0 and 10 feet bgs. Accordingly, this dataset includes all samples from both of the previous (surface) datasets as well as any additional samples from Areas 1 through 7 that began below the surface, but at a depth of less than 10 feet bgs. Many of the samples in this dataset are composites that extend to depths greater than 10 feet bgs.

The site is zoned for residential land-use; therefore, COPCs were identified by comparison of Site data to screening criteria based on EPA Region IX PRGs for residential soil exposures. These values were developed using the current EPA Region IX PRG Table (USEPA, 2000d), which identifies concentrations of potential concern for nearly 600 chemicals in various media (air, drinking water, and soil) using certain reasonable maximum exposure default assumptions. Region IX PRGs for carcinogens were taken directly from the Region IX PRG table. These PRGs are based on cancer risk levels of 1.0E-06. Region IX PRGs for non-carcinogens are based on a hazard quotient (HQ) of 1.0. The HQ is the ratio of an estimated dose to an established "safe" dose (the Reference Dose). In a risk assessment, HQs from multiple contaminants are added together to produce the total site hazard index (HI). Two or more contaminants present at or slightly below concentrations corresponding to their reference dose could yield a total site HI greater than the target HI of 1.0. If these contaminants act on the same target organ, adverse effects may occur. By setting the screening criteria at a concentration that would result in a dose that is one-tenth of the "safe" reference dose, the COPC selection protects against overlooking the presence of multiple contaminants that may produce additive effects. For this reason, Region IX non-carcinogenic PRGs were adjusted to COPC screening levels based on a target HQ of 0.1, which is one-tenth of the suggested cumulative target noncarcinogenic risk for a potential receptor. Screening values for non-carcinogenic contaminants whose Region IX PRGs are based on ceilings or soil saturation limits are adjusted to one tenth of the risk-based PRG developed prior to the application of ceiling or saturation limits.

The following chemicals were identified as COPCs based on a comparison of maximum site concentrations to risk-based COPC screening levels for residential land use:

- Semi-Volatile Organics (SVOCs): 1,4-dichlorobenzene, 4-methylphenol, and pentachlorophenol;

- Polynuclear Aromatic Hydrocarbons (PAHs): benzo(a)pyrene, 2-methylnaphthalene, and naphthalene;

- Polychlorinated Biphenyls (PCBs): Aroclor 1242;

- Metals: antimony, arsenic, barium, cadmium, chromium, lead, manganese, mercury, thallium, and vanadium;

- Dioxins.

Data evaluation and subsequent risk estimates for dioxins were evaluated through use of dioxin toxicity equivalents (TEQs). The Toxicity Equivalent Factors (TEFs), presented in Appendix J, were used to convert concentrations of individual dioxin and furan congeners to TEQs of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Concentrations of individual dioxins and furans were multiplied by their TEFs to yield 2,3,7,8-TCDD equivalent concentrations. These values were then totaled to yield total dioxin TEQs for each sample. These concentrations could then be compared to the screening toxicity value for 2,3,7,8-TCDD in the COPC selection step. In computing the dioxin TEQs for each sample, non-detected values were treated as one-half of the detection limit for those specific dioxin congeners that were positively detected in one or more samples within a data subset. One-half of the detection limit for non-detected dioxin results were included along with positive results in the TEQ summation for each sample.

Aluminum, cobalt, copper, and iron were not identified as COPCs because EPA Region I does not advocate quantitative risk assessment of the health effects of these metals because of the lack of adequate toxicity criteria.

Essential nutrients, including calcium, magnesium, potassium, and sodium, were not selected as COPCs.

Samples were analyzed both for total chromium and hexavalent chromium (chromium VI). Chromium VI was not detected in any sludge samples and in the two instances where it was detected at low concentrations in soil at the site (in Areas 5 and 6) the results were below chromium VI screening criteria. As a result, total chromium concentrations detected at the site were screened against trivalent chromium (chromium III) criteria. Chromium III was identified as a COPC based on comparison of maximum total chromium concentrations to chromium III screening values. Evaluation of risks from exposure to chromium were performed using chromium III toxicity values.

In general, similar contaminants were selected in each exposure area; however, the list of COPCs selected for Areas 1 through 7 “all soil” to a depth of 10 feet bgs was most inclusive.

2.4.2.2 Exposure Point Concentrations

Tables 2-23.1 through 2-23.3 present EPCs for quantitative risk evaluation for Area 1 surface sludge, Areas 2 through 7 surface soil and sludge, and Areas 1 through 7 soil and sludge from depths of 0 to 10 feet bgs, respectively. Current EPA risk assessment guidance (USEPA, 1992 and 1994b) was used to identify appropriate EPCs. When a sufficient number of samples were available, 95 percent upper concentration limits (UCLs) of the arithmetic mean were used as EPCs in estimating chemical intakes.

The methodology used for estimating the 95 percent UCL depends on the distribution of the sample set. For this risk evaluation, the distribution was determined using the Shapiro-Wilk W-Test (Gilbert, 1987). When the results of the test were inconclusive and the distribution was regarded as undefined, the distribution was assumed to be log normal and the 95 percent UCL for log-normally distributed data sets was selected as the EPC.

For normally distributed data, the calculation of the UCL is a two-step process. First the standard deviation of the sample set must be determined, as follows:

$$S = \left[\frac{\Sigma(X_i - \bar{X})^2}{(n-1)}\right]^{1/2}$$

where:

S = standard deviation

X_i = individual sample value

n = number of samples

$\bar{X}$ = mean sample value

The one-sided UCL on the mean is then calculated as follows:

$$UCL = \overline{X} + t\left(\frac{S}{n^{1/2}}\right)$$

where:

UCL	=	95 percent Upper confidence limit of the mean
$\bar{X}$	=	Arithmetic average
t	=	One-sided t distribution factor ($t_{0.95}$)
S	=	standard deviation
n	=	number of samples

For log-normally distributed data sets, the UCL is calculated using the following equation:

$$UCL = \exp\left(\overline{X} + 0.5\,s^2 + \frac{Hs}{(n-1)^{1/2}}\right)$$

where:

UCL	=	95 percent UCL of the mean
exp	=	Constant (base of the natural log, e)
$\bar{X}$	=	Mean of the transformed data
S	=	Standard deviation of the transformed data
H	=	H-statistic (from Gilbert, 1987; $H_{0.95}$)
n	=	Number of samples

This equation uses individual sample results that have been transformed by taking the natural logarithm of the results.

In data sets with 10 samples or less and data sets in which the calculated 95 percent UCL exceeded the maximum detected concentration, the maximum detected concentration was used as the EPC. EPCs used in the risk assessment are presented in Tables 2-23.1 through 2-23.3 and appear to the left in risk summary tables, Tables 2-25.1 through 2-25.3 and 2-26.1 through 2-26.3.

2.4.3 Exposure Assessment

The exposure assessment contains a discussion of the potential for human exposure at the site and identifies the exposure input parameters used to estimate exposure intakes and risks. A summary of the potentially significant exposures identified for quantitative evaluation for the site is provided in Table 2-21. Tables 2-24.1 through 2-24.3 present exposure parameters and exposure factor equations that incorporate exposure parameters into a single factor for use in determining chemical intake. These exposure factor equations and parameters also appear at the bottom of Tables 2-25.1 through 2-25.3 and Tables 2-26.1 through 2-26.3. The various assumptions used as input parameters to determine chemical intakes for each potential receptor and exposure route are discussed below.

The exposure assessment is based on the assumption that chemical compositions for environmental media are identical under current and future site conditions. Under current/future conditions, potential human receptors (adolescent trespassers) are assumed to be exposed to surface soil/sludge. As stated previously, the surface dataset includes any sample with a top depth of 0 feet bgs. Under future conditions, potential human receptors (residents) are assumed to be exposed to soil/sludge from a depth of 0 to 10 feet bgs ("all soil"). The "all soil" dataset includes any sample with a top depth of less than 10 feet bgs.

2.4.3.1 Potential Receptors

This evaluation quantifies risks to adolescent trespassers and to hypothetical future residents as identified in Table 2-21.

2.4.3.2 Adolescent Trespassers

Possible exposures of adolescent trespassers to site-related contaminants would be through recreational activities, such as walking, dirt biking, or exploring the edges of the open lagoon. Adolescent trespassers are evaluated for exposure to surficial soil/sludge at each of two exposure points, under current and future land use. Adolescent trespassers at Area 1 are assumed to contact surface sludge from the open lagoon while exploring the edge of the lagoon. Trespassers walking and dirt biking in drier areas of the site are expected to contact surface soil/sludge from Areas 2 through 7.

The trespasser is identified as an adolescent aged 9 through 18 years. The trespasser is exposed to site media primarily through incidental ingestion and dermal contact with soil and sludge. Exposure parameters including skin surface areas, body weights, and soil-to-skin adherence factors are shown on Tables 2-24.1 and 2-24.2 and in the exposure factor equations on the risk summary tables, Tables 2-25.1 and 2-25.2a and Tables 2-26.1 and 2-26.2a. Trespassers are assumed to be exposed to site media 26 days/year, corresponding to 1 day/week for 6 months of the year from May to October. These receptors are assumed to ingest an average of 100 mg/day. Feet, hands, forearms, and lower legs are expected to be available for dermal contact with soil/sludge. The soil-to-skin adherence value for trespassers in Area 1 was selected based on the 95^{th} percentile for children playing in mud. The soil-to-skin adherence value for trespassers in Areas 2 through 7 was selected based on the 95^{th} percentile for children playing in dry soil.

For trespassers exposed to soil/sludge from Areas 2 through 7, inhalation of fugitive dust during dirt biking activity was considered as a potential pathway. Inhalation pathway assumptions and equations are shown on Table 2-24.2. The inhalation rate for adolescents was set at 1.2 m^3/hr, occurring over 4 hours/day of exposure. The default particulate emission factor of 1.32E+9 m^3/kg was selected.

2.4.3.3 Residents

Possible exposures of hypothetical future residents to site-related contaminants would be through play and yard work at their homes. Residents are evaluated for exposure to surficial soil/sludge from any of the dry areas of the site (Areas 2 through 7) under future land use. In addition, residents are also evaluated for exposure to "all soil"/sludge from Areas 1 through 7 under future land use. This scenario assumes that soil and sludge currently located in any area of the site, from any depth between 0 to 10 feet bgs, may be brought to the surface during construction of homes on the site. It is assumed that the open lagoon in Area 1 has been covered with soil and the sludge has dried and may be brought to the surface and mixed with the cover soil.

Hypothetical future residents (ages 1 to 31 years) may be exposed to site media primarily through incidental ingestion and dermal contact with soil and sludge. Exposure through inhalation of dust was not considered a major exposure pathway for future residents because it is assumed that future grass cover would prevent significant dust. Future residents are assumed to be exposed to site media frequently (150 days/year). This exposure frequency is the EPA Region I default exposure frequency for residents and is based on the assumption that residential soil exposures in New England are limited to the warmer months of the year when the ground surface is neither frozen nor snow-covered. For noncancer risks, the 1 to 7-year old child is considered the most sensitive receptor and therefore is the receptor of concern. Residential receptors are assumed to ingest an average of 200 mg/day for 6 years for the child and 100 mg/day for 24 years for the adult. For children, head, hands, forearms, lower legs, and feet are expected to be available for dermal contact with soil. For adults, head, hands, forearms, and lower legs are expected to be available for dermal contact with soil. Soil-to-skin adherence factors (SSAFs) were selected based on EPA's recommended default values for residents. The adult SSAF is based on the 50^{th} percentile value for gardening, a high-end activity. The child SSAF is based on the 50^{th} percentile for children playing in wet soil, a high-end activity. Exposure assumptions, including ingestion rates, exposure frequencies, skin surface areas, body weights, soil-to-skin adherence factors, etc. are shown on Table 2-24.3 and in the exposure factor equations on the risk summary tables, Tables 2-25.2b and 2-25.3 and Tables 2-26.2b and 2-26.3. The exposure assumptions shown on Table 2-24.3 apply to residents exposed either to surface soil/sludge from any of the dry areas of the site (Areas 2 through 7) or to "all soil"/sludge from Areas 1 through 7.

2.4.3.4 Exposure Pathways

The primary routes of exposure for potential human receptors are incidental ingestion of and dermal contact with soil and sludge. Inhalation of fugitive dust was also considered for adolescent trespassers engaged in dirt-biking activity.

2.4.3.5 Chemical Intake

Estimates of chemical intake are calculated by multiplying EPCs by the exposure factor for the route of exposure. Chemical intakes are not presented separately, but are incorporated in the hazard index and cancer risk equations presented in Tables 2-25.1 through 2-25.3 and Tables 2-26.1 through 2-26.3.

hazard index and cancer risk equations presented in Tables 2-25.1 through 2-25.3 and Tables 2-26.1 through 2-26.3.

2.4.4 Toxicity Assessment

The toxicity assessment for the COPCs examines information concerning the potential human health effects of exposure to COPCs. The toxicity values presented in this section are integrated with the exposure assessment (Section 2.4.3) to characterize the potential for the occurrence of adverse health effects (Section 2.4.5).

Brief summaries of the toxicity profiles for the major COPCs are presented in Section 2.4.4.3

2.4.4.1 Noncarcinogenic Effects

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to a Reference Dose (RfD). The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. A RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs.

EPA is the primary source of information for Reference Dose values (USEPA, 1997b; USEPA, 2000c; USEPA, 2002). EPA's IRIS (Integrated Risk Information System) database (USEPA, 2002) was consulted as the primary source for RfD values, as well as for Cancer Slope Factors (CSFs). If values are not available in IRIS, the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b) were consulted, as well as the current Region IX EPA PRGs Table (USEPA, 2000d). Oral RfDs available from EPA sources represent administered toxicity values. Administered Reference Doses for the COPCs at the site are presented in Tables 2-25.1 through 2-25.3.

An absorbed RfD is developed by multiplying an administered RfD by the gastrointestinal tract absorption factor. The resulting absorbed RfD is used to evaluate dermal exposures and oral exposures when a reliable oral soil absorption factor is known. Absorbed RfDs and the absorption efficiencies used in their determination are included in Tables 2-25.1 through 2-25.3.

Inhalation RfDs are based on a conversion of Inhalation Reference Concentrations, available from the IRIS database. Inhalation RfDs for the COPCs at the site are presented in Table 2-25.2a.

PCB non-cancer risk characterization is addressed by evaluation of Aroclor 1242 concentrations, using the oral RfD for Aroclor 1254 since no RfD is available for Aroclor 1242. Aroclor 1242 was the only aroclor detected at concentrations exceeding screening criteria.

In the absence of significant concentrations of hexavalent chromium as determined by comparison of detected hexavalent chromium concentrations to respective screening values, evaluation of risks from exposure to total chromium concentrations were performed using chromium III toxicity values.

2.4.4.2 Carcinogenic Effects

The Cancer Slope Factor (CSF) is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. Slope factors are specific to a chemical and route of exposure and are expressed in units of $(mg/kg/day)^{-1}$. The primary source of information for CSFs is the EPA IRIS database, followed by other EPA sources described for non-carcinogens. Oral CSFs available from these EPA sources represent administered toxicity values. These administered CSFs for COPCs at the site are presented in Tables 2-26.1 through 2-26.3.

Absorbed CSFs are derived from the corresponding administered values. In the derivation of an absorbed CSF, the administered CSF is divided by the gastrointestinal absorption efficiency. Absorbed CSFs are used to evaluate dermal exposures and oral exposures when a reliable oral soil absorption factor is known. Absorbed CSFs and the absorption efficiencies used in their determination are also included in Tables 2-26.1 through 2-26.3.

Inhalation CSFs are based on a conversion of Inhalation Unit Risks, available from the IRIS database. Inhalation RfDs for the COPCs at the site are presented in Table 2-26.2a.

Risk estimates for dioxins were evaluated through the use of dioxin TEQs as described in Section 2.4.2.1. Dioxin TEQs were used in conjunction with the toxicity value for 2,3,7,8-TCDD in determining cancer risk.

PCB cancer risk characterization is addressed by evaluation of Aroclor 1242 concentrations only. This was the only aroclor detected at concentrations exceeding screening criteria. Aroclor 1254 was also detected, but at concentrations below the screening value.

2.4.4.3 Toxicity Summaries for Major Chemicals of Potential Concern

This section contains brief summaries of the toxicological profiles for the major COPCs.

Dioxins

The term “dioxin” refers to a group of 30 chemical compounds that share chemical structure and similar biological mechanisms of action (USEPA, 2000c). These compounds are members of three closely related families of chemicals: the chlorinated dibenzo-p-dioxins (CDDs), chlorinated dibenzofurans (CDFs), and certain polychlorinated biphenyls (PCBs). Dioxins are produced through combustion, chlorine bleaching of pulp and paper, certain types of chemical manufacturing and processing, and other industrial processes. PCBs were widely used as coolants and lubricants in electrical equipment before their manufacture in the United States was ended in 1977.

Dioxins are potent animal toxicants with a potential to produce a broad spectrum of adverse effects in humans. Dioxins can alter the fundamental growth and development of cells in ways that have the potential to lead to many kinds of impacts, including adverse effects upon reproduction and development; suppression of the immune system; chloracne (a severe acne-like condition that sometimes persists for many years); and cancer. The most studied and one of the most toxic dioxins is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). EPA characterizes 2,3,7,8-TCDD as a “human carcinogen” based on evidence of animal and human studies and characterizes other dioxins as “likely human carcinogens”. 2,3,7,8-TCDD is used as the basis for defining the toxicity of other dioxins.

Dioxins enter the ecological food web by being deposited from the atmosphere, either directly from air-emissions or indirectly by processes that return dioxins already in the environment to the atmosphere. Dioxins are highly persistent in the environment and can accumulate in the tissues of animals.

Antimony

Acute intoxication from ingestion of large doses of antimony induces gastrointestinal (GI) disturbances, dehydration, and cardiac effects in humans. Chronic effects from occupational exposure include irritation of the respiratory tract, pneumoconiosis, eruptions of the skin called "antimony spots," allergic contact dermatitis, and cardiac effects, including abnormalities of the electrocardiograph (ECG) and myocardial changes. Cardiac effects were also observed in rats and rabbits exposed by inhalation for six weeks and in animals (dogs, and possibly other species) treated by intravenous injection .

The EPA published a RfD for chronic oral exposure to antimony from a lifetime study of rats. The heart is considered a likely target organ for chronic oral exposure of humans.

Arsenic

Inorganic arsenic is a human poison. Organic arsenic is less harmful. High levels of inorganic arsenic in food or water can be fatal. Arsenic damages many tissues including nerves, stomach and intestines, and skin. Breathing high levels can cause a sore throat and irritated lungs. Lower levels of exposure to inorganic arsenic may cause nausea, vomiting, diarrhea, decreased production of red and white blood cells, abnormal heart rhythm, blood vessel damage, and a "pins and needles" sensation in hands and feet.

Long term exposure to inorganic arsenic may lead to a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. Direct skin contact may cause redness and swelling.

The U.S. Department of Health and Human Services (DHHS) has determined that arsenic is a known carcinogen. Breathing inorganic arsenic increases the risk of lung cancer. Ingesting inorganic arsenic increases the risk of skin cancer and tumors of the bladder, kidney, liver, and lung.

Chromium

Animal studies show that hexavalent chromium (chromium VI) is generally more toxic than trivalent chromium (chromium III), but neither oxidation state is very toxic by the oral route. The respiratory and dermal toxicity of chromium are well-documented. Compounds of both chromium VI and chromium III have induced developmental effects in experimental animals that include neural tube defects, malformations, and fetal deaths.

The inhalation of chromium compounds has been associated with the development of cancer in workers in the chromate industry. The relative risk for developing lung cancer has been calculated to be as much as 30 times that of controls. There is also evidence for an increased risk of developing nasal, pharyngeal, and gastrointestinal carcinomas. Based on sufficient evidence for humans and animals, chromium VI has been placed in the EPA weight-of-evidence classification A, human carcinogen. Chromium III is not classified as a carcinogen by EPA.

Lead

Unborn children and young children are particularly sensitive to the adverse effects of exposure to lead. Exposure to a fetus through its' mother may cause premature births, lower birth weight, and decreased mental ability of the infant. Lead exposure is dangerous for young children because they absorb lead at a greater rate than adults, retain more of the lead they ingest, and are more sensitive to its effects. Effects include decreased intelligence and decreased growth. EPA has classified lead as a B2 carcinogen based on the results of animal studies.

Manganese

Manganese is an essential trace element in humans that can elicit a variety of serious toxic responses upon prolonged exposure to elevated concentrations either orally or by inhalation. The central nervous system is the primary target. Initial symptoms are headache, insomnia, disorientation, anxiety, lethargy, and memory loss. These symptoms progress with continued exposure and eventually include motor disturbances, tremors, and difficulty in walking, symptoms similar to those seen with Parkinsonism. These motor difficulties are often irreversible.

Effects on reproduction (decreased fertility, impotence) have been observed in humans with inhalation exposure and in animals with oral exposure at the same or similar doses that initiate the central nervous system effects. An increased incidence of coughs, colds, dyspnea during exercise, bronchitis, and altered lung ventilatory parameters have also been seen in humans and animals with inhalation exposure.

4-Methylphenol (p-Cresol)

Three types of closely related cresols exist: ortho-cresol (o-cresol), meta-cresol (m-cresol), and para-cresol (p-cresol), also known as 4-methylphenol. Because these three types of cresols are manufactured separately and as mixtures, they can be found both separately and together. Cresols are natural products that are present in many foods and in animal and human urine. They are also present in wood and tobacco smoke, crude oil, and coal tar. In addition, cresols also are man-made and used as disinfectants and deodorizers, to dissolve substances, and as starting chemicals for making other chemicals.

Ingesting very high levels of cresols may result in a burning in the mouth and throat as well as stomach pains. Dermal contact with a substance containing high cresol levels may result in a rash or severe irritation. In some cases, a severe chemical burn might result. Through contact with high levels of cresols, for example, by drinking or spilling on the skin, one could experience anemia, kidney problems, unconsciousness, or even death.

It is possible that some of the acute effects in humans listed above, such as kidney problems and anemia, might occur at lower levels if exposure occurs over a longer time period. Effects on the nervous system, such as loss of coordination and twitching of muscles, are produced by low levels of cresols in animals, but it is not known whether low levels also cause such effects in humans. Cresols may enhance the ability of carcinogenic chemicals to produce tumors in animals, and they have some ability to interact with mammalian genetic material in the test tube, but they have not been shown to produce cancer in humans or animals. The EPA has determined that cresols are possible human carcinogens. Animal studies suggest that cresols probably would not produce birth defects or affect reproduction in humans.

Pentachlorophenol (PeCP)

PeCP is a man-made substance, made from other chemicals, and does not occur naturally in the environment. It is made by only one company in the United States. At one time, it was one of the most widely used biocides in the United States. Now the purchase and use of PeCPs are restricted to certified applicators. It is no longer available to the general public. Before use restrictions, PeCP was widely used as a wood preservative. It is now used industrially as a wood preservative for power line poles, cross arms, fence posts, and the like.

Short exposures to large amounts of pentachlorophenol in the workplace or through the misuse of products that contain it can cause harmful effects on the liver, kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract. Contact with PeCP (particularly in the form of a hot vapor) can irritate the skin, eyes, and mouth. If large enough amounts enter the body, heat is produced causing an increase in body temperature. The body temperature can increase to dangerous levels, causing injury to various organs and tissues and even death. This effect is the result of exposure to PeCP itself and not impurities. The lengths of exposure and the levels that cause harmful effects have not been well defined. Long-term exposure to low levels such as those that occur in the workplace can cause damage to the liver, kidneys, blood, and nervous system. Because sufficient reliable human exposure information is not currently available, levels of exposure that affect human health must be estimated from studies in animals. Results from animal studies show that short-term, high-level exposure to PeCP can damage all the organs mentioned above. The major organs or systems affected by long-term exposure to low levels in animals are the liver, kidney, nervous system, and the immune system. All of these effects worsen as the level of exposure increases.

In rats, slight changes in the formation of bones were seen in offspring of rats whose mothers were given PeCP orally. It is not known whether PeCP causes birth defects in humans. PeCP has also been shown to cause a decrease in the number of offspring born to animals that were exposed to it while they were pregnant, but it is not known if PeCP has this same effect in humans. An increased risk of cancer has been shown in some laboratory animals given long-term large amounts of PeCP orally, but there is no good evidence that PeCP causes cancer in humans.

The EPA has determined that PeCP is a probable human carcinogen. The classification is based on inadequate human data and sufficient evidence of carcinogenicity in animals: statistically significant increases in the incidences of multiple biologically significant tumor types (hepatocellular adenomas and carcinomas, adrenal medulla pheochromocytomas and malignant pheochromocytomas, and/or hemangiosarcomas and hemangiomas) in one or both sexes of B6C3F1 mice using two different preparations of PeCP. In addition, a high incidence of two uncommon tumors (adrenal medulla pheochromocytomas and hemangiomas/hemangiosarcomas) was observed with both preparations. This classification is supported by mutagenicity data, which provides some indication that PeCP has clastogenic potential.

Polyaromatic Hydrocarbons (PAHs)

Benzo(a)pyrene is the most widely studied chemical in this class. It is used as the basis for defining the toxicity of other potentially carcinogenic PAHs. Benzo(a)pyrene is widely distributed in the tissues of treated rats and mice but is primarily found in tissues high in fat. While the carcinogenicity of complex mixtures containing PAHs (such as coal tar, coke oven emissions, and cigarette smoke) is suggested, the carcinogenicity cannot be attributed solely to PAHs. The carcinogenicity of benzo(a)pyrene is based largely on the results of animal studies in which the animals were exposed to large doses of purified compound via atypical routes of exposure.

2.4.5 Risk Characterization

A summary of the quantitative risk evaluation for the site is provided in this section. Total noncarcinogenic hazard indices for each exposure route, as well as the cumulative hazard index, are presented in Tables 2-25.1 through 2-25.3. Total carcinogenic risks for each exposure route, as well as the cumulative risk, are presented in Tables 2-26.1 through 2-26.3. Table 2-27 presents the total health hazards and cancer risks for all scenarios.

- The estimated hazard index for residents exposed to surface soil/sludge from Areas 2 through 7 is 13.1. The estimated hazard index for residents exposed to “all soil"/sludge from Areas 1 through 7 is 72.4. Both of these scenarios exceed a total hazard index of 1.0, the threshold for potential non-carcinogenic effects and the EPA target level of concern. Prime contributors to the hazard index are antimony, chromium, manganese, and 4-methylphenol which each, individually, have hazard quotients exceeding 1.0.

- The estimated hazard index for trespassers in Area 1 is 42.5, due primarily to 4-methylphenol. The hazard quotient for antimony also exceeds 1.0 in this scenario.

- The estimated hazard index for trespassers in Area 2 through 7 is 0.35. This value is less than the EPA target level of concern of 1.0.

- The cancer risk estimate for residents exposed to surface soil/sludge from Areas 2 through 7 is 9.5E-05, within EPAs target cancer risk range of 1E-04 to 1E-06. The cancer risk estimate for residents exposed to “all soil"/sludge from Areas 1 through 7 is 1.9E-04. This cancer risk estimate exceeds EPAs target cancer risk range of 1E-04 to 1E-06, due primarily to dioxin. The cancer risk estimates for pentachlorophenol, arsenic, and benzo(a)pyrene also exceed 1E-06 in this scenario. Benzo(a)pyrene was detected only in a very localized area of the site, in one sample from Area 7. It does not appear to be a site-wide concern.

- The cancer risk estimate for trespassers in Area 1 is 1.9E-03. This cancer risk estimate exceeds EPAs target cancer risk range of 1E-04 to 1E-06, due primarily to dioxin and pentachlorophenol. The cancer risk estimate for arsenic also exceeds 1E-06 in this scenario.

- The cancer risk estimate for trespassers in Area 2 through 7 is 5E-06. This cancer risk estimate falls within EPAs target cancer risk range of 1E-04 to 1E-06.

Since lead cannot be evaluated using hazard index and/or cancer risk methodology, a qualitative comparison of site data to EPA’s Office of Solid Waste and Emergency Response (OSWER) soil screening level of 400 mg/kg for residential land use (USEPA, 1994a) was performed. The EPA’s Integrated Exposure Uptake and Biokinetic (IEUBK) model, which estimates the risk to a child resident is the basis for this soil screening level. Lead concentrations exceeding 400 mg/kg are found in only one sample, collected from Area 7. The maximum detected lead concentration is 427 mg/kg.

2.4.6 Uncertainties

Uncertainties associated with the various aspects of this risk evaluation include the following:

- The limited number of samples within each exposure point subgroup results in the use of maximum detected concentrations for all evaluations of exposures to surface materials. In addition, the limited number of samples in the "all soil" dataset resulted in the use of maximum concentrations for several contaminants.

- The use of composite samples collected from several locations or a large depth interval may under-estimate or over-estimate actual risks. Since composite samples represent an average concentration over the sampling interval, this can lead to under-estimating the risk presented by a discrete and more highly contaminated zone located within the sampling interval or over-estimating the risks presented by a discrete and less contaminated zone located within the sampling interval.

- Selection of high-end exposure parameters may overestimate actual exposures.

- Toxicity values based on animal studies introduce a degree of uncertainty to the risk characterization process.

- Use of the currently available dioxin cancer slope factor from IRIS (USEPA, 2002) may underestimate risks from dioxin exposure. EPA has recently prepared a Draft Dioxin Reassessment, which recommends a dioxin CSF of 1.0E+6. Appendix K presents the cancer risks for the Mohawk Tannery Site using this proposed dioxin CSF. Cancer risks estimated using this draft approach are approximately an order of magnitude greater than risks calculated using the current dioxin CSF.

2.5 <u>Streamlined Ecological Risk Evaluation</u>

The evaluation for the Mohawk Tannery Site was performed as a Screening-Level Ecological Risk Assessment (SERA), in order to satisfy the needs of the project and to comply with Region I U.S. EPA Guidance. The goal of the evaluation and the SERA is to estimate the current level of risk to ecological receptors, using conservative screening values and exposure assumptions. This is being done to determine what contaminants at the site may merit removal for protection of the environment.

The SERA provides the first two of eight steps required by the U.S. EPA guidance (USEPA, 1997a and 1998c). Figure 2-4 presents the Ecological Risk Assessment (ERA) Tiered Approach. The first two steps consist of the screening-level assessment. Steps 3 through 7 are conducted if additional evaluations or investigations are necessary based on the results of the first two steps. Finally, Step 8, Risk Management, is incorporated throughout the ERA process, in cooperation with the EPA Region I Biological Technical Assistance Group (BTAG).

2.5.1 Ecological Risk Assessment Approach

The first phase in the ERA process is the screening-level risk assessment. In this phase, conservative exposure estimates are made for grouped or individual ecological receptors, and these exposures are compared to screening-levels, or threshold toxicity values. The following general steps were followed for the SERA:

- Problem formulation
- Exposure Assessment
- Ecological Effects Assessment
- Risk Characterization

The process, described in detail below, follows the ERA approach in EPA guidance (USEPA, 1997a and 1998c).

2.5.2 Problem Formulation

Problem formulation is the first phase of a SERA and discusses the goals, breadth, and focus of the assessment. It includes general descriptions of the site with emphasis on habitats and ecological receptors. This phase also involves characterization of site contaminants, contaminant sources, migration pathways, and an evaluation of routes of contaminant exposure. Assessment and measurement endpoints are selected. Finally, a conceptual model is developed that describes how contaminants associated with the site may come into contact with ecological receptors. The following sections provide the problem formulation steps for the Mohawk Tannery site.

2.5.2.1 Site Characterization

The objectives of this step are to identify and characterize the habitats and ecological resources on and around the site, and to describe the nature and extent of chemical contamination associated with the site. The site characterization also describes likely contaminant sources, release mechanisms, and migration pathways, and the fate of chemicals resulting from site-related activities, as well as ecological resources that could be adversely affected by these chemicals.

Regional Setting

The site includes real property of the inactive Mohawk Tannery, located about 1 mile west of the center of Nashua, New Hampshire, and adjacent to the Nashua River (Figure 1-2). The property includes a 15-acre parcel containing buildings and waste disposal areas and a 15-acre parcel to the south that is not developed. All of the samples discussed in the assessment were taken in the developed parcel to the north (Figure 1-3).

The site is surrounded by the Nashua River to the west, a closed landfill to the north, and residential areas to the south and east. The main buildings are in the eastern portion of the site, where the elevation is highest. Waste disposal areas are located along the slope down to the river, which is steep in some areas and eventually becomes more level on the river's floodplain. Areas 3 through 7 are situated along the hillside, while Areas 1 and 2 are on nearly level ground near the river. The floodplain is very narrow on the northern end of the property where the river runs by a steep hill, and more broad at the southern end. The undeveloped, southern 15-acre parcel appears to be predominately floodplain, including some wetland areas.

Vegetative Cover Types

Vegetation and wildlife were noted during TtNUS' sampling events and on a brief site visit in January, 2002. Each sampling area is described below in reverse order (Area 7 to Area 1), that is roughly the sequence from east to west and from higher to lower elevation (Figure 1-3). Area

7 is southwest of, and adjacent to, the main building and is bordered to the east and south by mature oak-hickory woods. Area 7 has small cherry, aspen, and ash trees scattered among herbaceous growth and a large amount of debris, such as piping, wood, and electronic components. Area 6 is covered with demolished buildings and treatment system components and with much concrete remaining among scattered herbs. Area 5 abuts the hillside to the north of the property and, together with Area 4, shows the lowest level of disturbance among the areas. It is covered by oak, white pine, aspen, sumac, cherry, ash, and large herbs. The trees approach 20 to 25 feet in height. Area 4 is down slope from Area 5 and partially in the river's floodplain. It contains oak, ash, red maple, and cherry. The hillside north of Areas 4 and 5 (beyond the fence line) is covered by large hardwoods with a lesser number of pine trees.

Area 3 contains an old field assemblage of aspen, white pine, cherry, birch, oak, sumac, and large herbs, similar to the other upland areas. Area 2 is flat and in the floodplain; it is surrounded by the common reed (*Phragmites*), with some birch and red maple. The common reed is typically seen as a monoculture, like it is in Area 2, in low-lying areas that have been disturbed. About 50 percent of Area 1 is an open lagoon with surface water and the other half is covered by reed. It is the only area containing sludge from tannery waste treatment that has not been covered with soil. The water is about 1 foot deep.

The Preliminary Ecological Risk Evaluation for the Mohawk Tannery (Lockheed Martin) lists rare plants within 0.25 to 4 miles of the site, based on information in the Final Site Inspection Prioritization Report (NHDES, 1996). Given the level of disturbance on the site, especially in areas likely to contain contaminants, it is unlikely that rare plants are currently being harmed by site chemicals.

<u>Wildlife Habitat</u>

The upland part of the site is used by red-tailed hawks, crows, bluejays, and other songbirds. Sightings or signs were made of white-tailed deer, woodchuck, raccoon, beaver, rabbit, and rodent-sized mammals. Although likely to be domestic, cat and dog sign or sightings were also noted. The lagoon (Area 1) has had painted turtles, bull frogs, green frogs, mallards, and Canada geese.

The Nashua River is an important component of regional wildlife habitat. It is a large waterway, about 160 feet wide where it abuts the site. Mallards were observed during the January site visit. The river is likely to be important for migrating waterfowl as well as permanent residents. An aerial photograph of the site vicinity shows a continuous matrix of forests, wetlands, and parkland along the river. It seems likely that these natural (or at least uninhabited) lands form a corridor of wildlife habitat that would support local and migratory populations of birds, mammals, and other animals. Also, the river is stocked with shad and alewife, and its tributaries are stocked with trout (Lockheed Martin). The river is known to support yellow perch, sunfish, and largemouth bass.

2.5.2.2 Toxicity Profiles

VOCs, SVOCs, pesticides and PCBs, dioxins, and metals were detected in one or more of the sampled media (soil, sediment, and surface water). The following sections present a brief discussion regarding the toxicity, potential food chain and trophic transfer, and fate and transport properties of each class of contaminants.

Tables 2-28 through 2-30 present statistics for detected analytes. These tables are presented for the media sampled: surface soils (data for Areas 2 through 7 combined), sediment/sludge (Area 1), and surface water (Area 1).

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioconcentration factors (BCFs), biota-to-sediment accumulation factors (BSAFs), organic carbon partition coefficients, and octanol water partition coefficients. These factors are discussed in the following subsections, as necessary. The following paragraphs discuss the significance of each factor. The sections that follow present a discussion of each chemical class that was detected in each medium.

Bioconcentration factors measure the tendency for a chemical to partition from the water column and concentrate in aquatic organisms. The BCF is the equilibrium concentration of a chemical in an organism divided by the concentration of the chemical in water. Chemicals with high BCFs can accumulate in lower-order species and become toxic to, or accumulate further in, species higher up the food chain.

Biota-sediment accumulation factors (BSAFs) can be used to predict contaminant concentrations in fish or invertebrate tissue from contaminant concentrations in sediment. BSAFs for the organic compounds can be obtained from The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 1: National Sediment Quality Survey (USEPA, 1997c). BSAFs for inorganic chemicals in fish are not available.

The organic carbon partition coefficient (K_{oc}) measures the tendency for a chemical to partition between soil or sediment particles containing organic carbon and water. This coefficient is important because it determines how strongly an organic chemical will bind to the organic carbon in the sediment. Bound chemicals are likely to be unavailable for direct exposure.

The octanol/water partition coefficient (K_{ow}) is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and with adsorption to soil or sediment (i.e., with K_{oc}).

Metals

Many metals are found naturally in the surface water, sediment, and/or soil due primarily to chemical weathering of rock and soil/sediment and fallout from volcanoes. Most metals are toxic to aquatic (i.e., fish, and invertebrates) and terrestrial (i.e., plants, invertebrates, and vertebrates) ecological receptors at certain concentrations, with some metals being more toxic at lower concentrations than others. Also, different chemical forms of the metals may be more toxic than other forms. For example, hexavalent chromium is typically more toxic than trivalent chromium, and methylmercury is more toxic than inorganic mercury. In addition, the toxicity of several metals (cadmium, chromium, copper, lead, nickel, silver, and zinc) to aquatic receptors in freshwater systems decreases with increasing water hardness.

Only a portion of the total bulk concentration of metals in soils is bioavailable to ecological receptors. The uptake and accumulation of trace elements by plants are affected by several soil factors such as pH, Eh, clay content, organic matter content, cation exchange capacity, nutrient balance, concentration of other trace elements in soil, soil moisture, and temperature (Tarradellas et al., 1996). This makes the bioavailability of metals in soil very difficult to predict.

Many of these same factors also will influence the bioavailability of metals to invertebrates in sediment.

Of the 29 elements essential for plant growth, seven are micronutrients, including copper, iron, manganese, and zinc (Tarradellas et al., 1996). Also, the following metals may stimulate plant growth but are only essential for some plant species: aluminum, cobalt, nickel, sodium, selenium, and vanadium (Tarradellas et al., 1996). Finally, some elements such as lead, cadmium, and mercury are toxic elements with no known function in plant metabolism (Tarradellas et al., 1996).

Oak Ridge National Laboratory (ORNL, 1998) has calculated soil-to-plant uptake factors for several metals based on a compilation of various studies. Soil to plant uptake factors for some metals that are not listed in ORNL 1998 are listed in ORNL (2000). Cadmium, mercury, selenium, and zinc were the only metals (except for calcium and potassium) with mean uptake factors greater than one (1.02 to 2.25). Arsenic, cadmium, mercury, nickel, selenium, and zinc were the only metals (except for calcium, magnesium, and potassium) with upper 90th percentile uptake factors greater than one (1.1 to 5) (ORNL, 1998). This indicates that most metals will not biomagnify in plants. Finally, it is reported that for arsenic, copper, nickel, and zinc, the plant-based food chain may be protected because the toxic concentrations of these metals in plants are higher than those for animals, while cadmium and selenium are not toxic to plants at high concentrations and may be accumulated in plants at levels that may be toxic to animals (Cockerham and Shane, 1994). Other metals such as lead, cobalt and mercury can enter the food chain via plant uptake, but to a lesser extent (Cockerham and Shane, 1994).

Cadmium appears to accumulate in most species of earthworms at greater levels than any other metal (Satchell, 1983). This is supported by the high mean soil-to-earthworm uptake factor of 17 for cadmium, compared to mean uptake factors of 5.7 (zinc), 5.2 (mercury), 4.5 (silver), and 3.3 (lead) (Sample et al., 1998). The remaining metals (except potassium, sodium, and some radionuclides) had mean uptake factors below 1.8 (Sample et al., 1998). Cadmium, mercury, nickel, silver, and zinc are the only metals with median uptake factors greater than one (Sample et al., 1998). The upper 90th percentile uptake factors were 40.7, 20.6, 15.3, and 12.9 for cadmium, mercury, silver, and zinc (Sample et al., 1998). The remaining metals had upper 90th percentile uptake factors of 4.7 or less. Chromium is not accumulated in earthworms; chromium concentrations in worm are similar to soil concentrations (Sample et al., 1998).

Semivolatile Organic Compounds

Phenolic compound, a few PAHs, and some phthalates make up the SVOCs that were detected in the surface water, sediment, and surface soil samples from the site

The phenolic compounds found at the Mohawk Tannery site include phenol, 2,4,5-trichlorophenol, 4-methylphenol, and pentachlorophenol. Phenol is highly mobile in the environment and is expected to biodegrade rapidly under favorable conditions for microbes (HSDB, 2002). Favorable conditions include appropriate substrate concentrations and the availability of microbial populations, nutrients, and suitable temperatures. 4-Methylphenol has similar characteristics, but it has a higher K_{oc} and therefore may be retained to a small extent in soil and sediment. Both phenol and 4-methylphenol do not bioaccumulate. In contrast, pentachlorophenol is expected to bind to sediment and soil, biodegrade slowly, and accumulate in the biota. Trichlorophenol is expected to have fate and transport characteristics that are intermediate between phenol and pentachlorophenol.

PAHs are a diverse group of compounds consisting of two or more substituted and unsubstituted polycyclic aromatic rings. PAHs are transferred from surface water by volatilization and sorption to settling particles. The compounds are transformed in surface water by photooxidation, chemical oxidation, and microbial metabolism (ATSDR, 1989a). In soil and sediments, microbial metabolism is the major process for degradation of PAHs (ATSDR, 1989a). Although PAHs accumulate in terrestrial and aquatic plants, many organisms are able to metabolize and eliminate these compounds. Vertebrates can readily metabolize PAHs, but lower forms (insects and worms) can not metabolize PAHs as quickly. Food chain uptake does not appear to be a major exposure source to PAHs for aquatic animals (ATSDR, 1989a).

Plants and vegetables can absorb PAHs from soil through their roots and translocate them to other plant parts such as developing shoots (Eisler, 1987). In general, however, PAHs are not readily taken up by plants because these compounds are strongly adsorbed onto soil organic particles and root uptake is very inefficient (Donker, et al., 1994). Lower molecular weight PAHs (which would be more water soluble) are absorbed by plants more readily than higher molecular weight PAHs. This is indicated by the low (well below 1.0) soil-to-plant uptake factors, which were calculated using the K_{OW} for the contaminants (ORNL, 2000). Finally, many higher plants can catabolize benzo(a)pyrene and possibly other PAHs (Eisler, 1987).

PAHs vary substantially in their toxicity to aquatic organisms. In general, toxicity increases as molecular weight increases, with the exception of some high molecular weight PAHs that have low acute toxicity. Most species of aquatic organisms rapidly accumulate PAHs from low concentrations in the ambient medium. However, uptake of PAHs is highly species specific, it is higher in algae, mollusks, and other species that are incapable of metabolizing PAHs (Eisler, 1987). The ability of fish to metabolize PAHs may explain why benzo(a)pyrene is frequently not detected or is found at only very low levels in fish from environments heavily contaminated with PAHs (ATSDR, 1989a). The BSAF value for the PAHs as reported by EPA (USEPA, 1997c) was 0.29.

Phthalates are compounds that are used in production of plastics (ATSDR, 1993). Most phthalates are expected to sorb to soil or sediment particles after their release because of their high Log K_{OC} values (Howard, 1989). Some phthalates may bioconcentrate in aquatic organisms (Spectrum Laboratories, 1999; Howard, 1989; ATSDR, 1993).

Pesticides

The majority of the pesticides that were detected at the site include the organochlorine insecticides such as DDT, chlordane, aldrin, dieldrin, heptachlor, and endrin and their associated breakdown products. In general, these compounds degrade very slowly and tend to be soluble in lipids, which results in bioaccumulation and possible increases in concentrations through food webs (Newman, 1998).

Pesticides are used to control pestiferous invertebrates and, therefore, they are toxic to many soil and aquatic invertebrates. In addition, many pesticides are toxic to higher trophic level ecological receptors such as mammals and birds. For example, DDT compounds have been linked to eggshell thinning and subsequent decreased survival of several birds of prey (such as eagles and falcons). Other pesticides such as chlordanes, dieldrin, aldrin, endrin, and heptachlor also are very toxic to mammals and birds (Newell et al., 1987).

Chlorinated pesticides have high Log K_{OC} values so they are expected to sorb strongly to soil and sediment particles when released to the environment. Consequently, these compounds are not easily displaced from their site of application, whether by runoff or leaching to groundwater.

As a result, these compounds typically will not be taken up by plants as indicated by their soil-to-plant uptake factors, which are well below 1.0 (ORNL, 2000).

PCBs

PCBs are a group of compounds that consist of two joined benzene rings and up to 10 chlorine atoms. Mixtures of PCB congeners are known by their commercial designation of Aroclor. This trade name is followed by a four-digit number; the first two numbers indicate the type of isomer mixture and the last two numbers indicate the approximate weight percent of chlorine in the mixture (USEPA, 1985).

PCBs released into water adsorb to sediments and other organic matter. Typically, PCB concentrations are greater in the sediment and suspended material than in the water column. Substantial quantities of PCBs in aquatic sediments can act as an environmental reservoir from which PCBs may be released slowly over a long period of time (ATSDR, 1989d). For PCBs that exist in the dissolved state in water, volatilization becomes the primary fate process. PCBs have the capability to bioaccumulate and biomagnify (USEPA, 1985).

Degradation of PCBs in the environment is dependent upon the degree of chlorination. Generally, the more chlorinated the PCB molecule, the more persistent it will be in the environment. Factors that determine biodegradability include the amount of chlorination, concentration, type of microbial population, available nutrients, and the temperature (ATSDR, 1989d).

PCBs are expected to be highly immobile in the soil due to rapid and strong sorption (ATSDR, 1989d). Some data indicate that plants are capable of taking up PCBs and transferring them into polar metabolites or insoluble molecules (Donker et al., 1994). However, it is unlikely that uptake and transformation of these compounds occur to any great extent, because a large part (greater than 95 percent) will adsorb to the root surface (Donker et al., 1994). The soil-to-plant uptake factors for PCBs on a wet weight basis range from 0.00059 to 0.11 (ORNL, 2000). The transfer of vapor-phase PCBs from air to aerial plant parts may be the main source of vegetation contamination (ATSDR, 1989d).

Because PCBs are highly lipophilic (fat soluble), they can bioaccumulate in the fat of animal tissues. Bioconcentration factors in the thousands have been reported for various aquatic species (Eisler, 1986a). PCBs also can accumulate in upper trophic level animals such as piscivorous birds and mammals that feed on contaminated prey (Eisler, 1986a). Finally, Sample et al. (1998) calculated mean, median, and 90th percentile reported soil-to-earthworm bioaccumulation factors (BAF) of 8.9, 6.7 and 15.9, respectively, indicating the PCBs can accumulate in soil invertebrates.

Adverse effects of PCBs on terrestrial wildlife include increased mortality, reproductive effects, and behavioral effects (USEPA, 1985). As a group, birds are more resistant to acute toxic effects of PCBs than mammals (Eisler, 1986a). Among sensitive avian species, PCBs disrupt the normal pattern of growth, reproduction, metabolism, and behavior (Eisler, 1986a). Of the mammals, the mink is the most sensitive wildlife species tested for which data are available (Eisler, 1986a). Impacts to mink include anorexia, weight loss, lethargy, reproductive effects, and death (Eisler, 1986a).

Volatile Organic Compounds

VOCs are usually very mobile in the environment because they are poorly adsorbed to soil and sediment particles. Also, because they are very volatile, they typically are only detected in surface waters and surface soils at low concentrations.

Most VOCs have very little potential to bioaccumulate in ecological receptors; therefore, biomagnification through the food chain does not appear to be significant. VOCs are not expected to biomagnify in plants and are typically only toxic to ecological receptors only at relatively high concentrations.

Dioxins

Dioxins and dioxin-like compounds consist of the following chemical classes: polychlorinated dibenzo-p-dioxins (PCDDs or CDDs), polychlorinated dibenzofurans (PCDFs of CDFs), polybrominated dibenzodioxins (PBDDs or BDDs), polybrominated dibenzofurans (PBDFs or BDFs), and PCBs (USEPA, 1998d). The CDDs and BDDs each include 75 individual compounds, and the CDFs BDFs each include 135 different compounds (USEPA, 1998d). Of all these compounds, only 7 of the 75 congeners of CDDs or BDDs are thought to have dioxin-like toxicity, as are 10 of the 135 congeners of CDFs, or BDFs (USEPA, 1998d). These are the ones with chlorine/bromine substitutions in, at least, the 2, 3, 7, and 8 positions (USEPA, 1998d). Of the 209 PCB congeners, 13 are thought to have dioxin-like toxicity, which include the PCBs with four or more chlorine atoms with just one or no substitution in the ortho position (USEPA, 1998d).

2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic congener within these groups of compounds (Van den Berg et al., 1998). There are few toxicity data for dioxins except for 2,3,7,8-TCDD, which has been associated with lethal, carcinogenic, teratogenic, reproductive, mutagenic, histopathologic, and immunotoxic effects (Eisler, 1986b). Because of this, toxicity equivalency factors (TEFs) have been developed to estimate the relative toxicity of the dioxin and dioxin-like compounds to 2,3,7,8-TCDD (Van den Berg et al., 1998). There are substantial inter- and intraspecific differences in sensitivity and toxic responses to 2,3,7,8-TCDD (Eisler, 1986b).

Two species of earthworms showed no adverse effects at soil concentrations of 5 mg/kg; however, they died at 10 mg/kg of 2,3,7,8-TCDD (Eisler, 1986b). This indicates that terrestrial invertebrates may be resistant to 2,3,7,8-TCDD. Eisler (1986b) also reported that aquatic invertebrates, plants, and amphibians were comparatively resistant to 2,3,7,8-TCDD; however, accumulation from the aquatic environment was evident.

Although there presently is no evidence of biomagnification of PCDDs in birds, it is suspected that piscivorous birds have a greater potential to accumulate PCDDs than the fish that they eat (Eisler, 1986b).

2.5.2.3 Identification of Exposure Pathways and Potential Receptors

The potential pathways by which ecological receptors may be exposed to contaminants in each media were identified along with the species that could be adversely affected by these chemicals. Several potential exposure pathways may exist at the site as shown in the conceptual site model (Figure 2-5).

Conceptual Site Model

The sources of contamination at the site are presumed to be a result of releases from the former tanning and wastewater treatment operations at the site. A more detailed description of the processes leading to releases is in discussed Section 1.2.2. The contaminants were primarily collected in sludge formed during wastewater treatment, and disposed in soil pits that are now Areas 3 through 7. Other areas received releases directly from the wastewater handling system and potentially from other waste handling practices. Area 1 is a former wastewater treatment lagoon that contains contaminated sludge, and Area 2 is a former lagoon that has been covered with fill.

Terrestrial and aquatic species may be exposed to contaminants via different pathways including direct contact, ingestion of contaminated media, and inhalation of contaminants. Exposure of terrestrial wildlife to contaminants in the soil via dermal contact may occur, but is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons probably minimize transfer of contaminants across dermal tissue (note that this may not be true for amphibians). Therefore, the dermal pathway was not evaluated in this SERA, with the exception of aquatic organisms (i.e., benthic invertebrates, amphibians) since the surface water criteria take dermal contact into account through the nature of the tests. In addition, the inhalation pathway was not evaluated because air concentrations are expected to be minimal since that majority of the area is vegetated and/or wet. Also note that the dermal and inhalation pathways typically are not evaluated in SERAs because of the uncertainty in exposures and effects concentrations. Terrestrial vegetation may be exposed to contaminants via direct aerial deposition and root translocation.

Terrestrial and semi-aquatic animals may be exposed to soil/sediment contaminants through ingestion of contaminated food items (i.e., plants, invertebrates, mammals, birds, fish, etc.). Animals can also incidentally ingest soil/sediment while grooming fur, preening feathers, digging, grazing close to the soil/sediment, or feeding on items to which soil/sediment has adhered (such as roots and tubers). Terrestrial animal receptors may also come into contact with contaminants in surface water by drinking the water, although this exposure route represents a negligible portion of total exposure for most receptors because of the relatively low contaminant concentrations in surface water as compared to other media.

Terrestrial invertebrates and vegetation may be exposed to contaminants in the surface soil via direct contact. Finally, aquatic organisms may be exposed to contaminants via direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items.

Based on the identification of contaminants and exposure pathways, five species groups were selected for evaluation in the risk assessment. These include terrestrial plants, terrestrial invertebrates, terrestrial and semi-aquatic vertebrates (mammals and birds), and aquatic receptors as shown on Figure 2-5.

Selection of Receptor Species

Many receptors in the soil and aquatic environments are adequately described in general categories such as soil invertebrates, vegetation, and sediment-dwelling (benthic) invertebrates. This is due to the nature of the threshold values, effects values, or water quality criteria that are typically used to characterize risk for such organisms. For vertebrate receptors, selection of particular species may be required so that intake through eating, drinking, and other routes can be estimated.

Receptor identification is influenced by the contaminants, their likely mode of transport, ultimate fate, and toxicity. For example, most metals (with notable exceptions of cadmium and mercury) typically do not bioaccumulate. For contaminants that bioaccumulate, such as mercury compounds and chlorinated pesticides, effects on upper trophic level receptors need to be assessed. For contaminants that do not bioaccumulate, organisms that are in direct contact with soil/sediment (i.e., sediment- and soil-dwelling organisms and plants) and animals that may incidentally ingest soil particles are selected as receptors for metals if exposure pathways are complete. Sensitivity to particular contaminants is also considered. For example, birds and mammals may have different sensitivities to organic compounds, so each group, or the most sensitive group for a particular contaminant, is assessed.

2.5.2.4 Identification of Assessment Endpoints and Measures of Effects

Assessment endpoints are an explicit expression of the environmental value that is to be protected (USEPA 1997a). The selection of these endpoints is based on the habitats present, the migration pathways of probable contaminants, and the routes that contaminants may take to enter receptors. Measures of effects are estimates of biological impacts (i.e., mortality, reproduction) that are used to evaluate the assessment endpoints. The selection of measurement endpoints is based on available data.

As indicated in Section 2.5.2.1, the habitat at the site consists largely of old field vegetation in various stages of development after disturbance, plus an open lagoon and a former lagoon covered with the common reed. Although different receptors may preferentially inhabit one particular habitat type, the assessment endpoints selected for this SERA are general enough to ensure that all the habitat types are evaluated. Therefore, for this SERA, the assessment endpoints are selected for protection of the following groups of receptors from adverse effects of contaminants on their growth, survival, and reproduction:

- Soil invertebrates
- Terrestrial Vegetation
- Herbivorous mammals
- Herbivorous birds
- Carnivorous Birds
- Carnivorous Mammals
- Omnivorous mammals
- Omnivorous birds
- Benthic invertebrates
- Fish
- Amphibians and reptiles

The following paragraphs discuss why assessment endpoints were selected to protect these groups of receptors for this SERA.

Soil Invertebrates: Soil invertebrates are expected to be present in the soil throughout the area. They aid in the formation of soil, redistribution and decomposition of organic matter in the soil and serve as a food source for higher trophic level organisms. They also can accumulate some contaminants, which can then be transferred to the higher trophic level organisms that consume invertebrates.

Terrestrial Vegetation: Terrestrial vegetation in the area consists of grasses, herbs, shrubs, and trees. They serve as a food source and provide shade and cover for many organisms, and help prevent soil erosion, among other important functions. They also can accumulate some contaminants, which can then be transferred to the higher trophic level organisms that consume plants (herbivores).

Herbivorous Birds and Mammals: Herbivorous birds and mammals (animals that consume only plant tissue) are present throughout the area in the different terrestrial habitats (i.e., forested, open field). Their role in the community is essential because without them, higher trophic levels (carnivores) could not exist (Smith, 1966). They may be exposed to, and accumulate contaminants that are present in the plants they consume.

Carnivorous Birds and Mammals: Carnivorous birds and mammals consume invertebrates and other mammals or birds. Soil invertebrate-eating birds and mammals are present throughout the area in the different terrestrial habitats (i.e., forested, open field). These animals are considered first-level carnivores and they serve as a food source for higher trophic level carnivores. Carnivorous birds and mammals that feed on other birds and mammals are at the top of the food chain. The top carnivores typically are less densely distributed than the herbivores and first-level carnivores because they require a larger area to hunt for their food. All of the carnivores may be exposed to and accumulate contaminants that are present in the food items they consume.

Omnivorous Birds and Mammals: Omnivorous birds and mammals (that consume both plant and animal tissue) are present throughout the area. They may be exposed to, and accumulate, contaminants that are present in the plants and animals they consume.

Benthic Invertebrates: Benthic invertebrates are similar to the soil invertebrates in that they serve as a food source for higher trophic level organisms (i.e., fish, amphibians, reptiles, birds, mammals). They also can accumulate some contaminants, which can then be transferred to the higher trophic level organisms that consume invertebrates.

Fish: Fish may or may not be present in the open lagoon. They are definitely in the Nashua River, and may be exposed to site contaminants that reach, or could reach, the river. Fish feed primarily on invertebrates, plants, and/or other fish, which is why the lower trophic level species are important. Fish are exposed to and can accumulate contaminants from the food they consume, or from the surface water in which they live.

Amphibians and Reptiles: Amphibians are expected to inhabit water bodies and surrounding areas. Reptiles can inhabit both aquatic and terrestrial areas that are away from water bodies. These species feed primarily on invertebrates, plants, fish, and/or small mammals, explaining why the lower trophic level species are important. Amphibians and reptiles are exposed to and can accumulate contaminants from the food they consume, or from the surface water/sediment in which they live.

The omnivores were not selected as assessment endpoints because exposure to contaminants in plants will be highest for herbivores and exposure to contaminants in animals will be highest for carnivores. Therefore, the omnivores should be protected by protecting the herbivores and carnivores.

The following text summarizes the assessment endpoints selected to protect the receptors identified above, poses risk questions, and presents the measures of effects to answer the risk questions.

Assessment endpoint #1: Aquatic invertebrate communities exposed to surface water and sediment, which are a forage resource for fish and wildlife populations.

- Question 1-1: Do measured concentrations of analytes in surface water exceed appropriate criteria and/or guidelines for the protection of aquatic life, with special consideration of reproduction and early life stage survival?

- Measure of Effect: Compare surface water concentrations to federal recommended water quality criteria, and/or data from aquatic toxicology literature.

- Question 1-2: Do measured concentrations of analytes in whole sediment exceed appropriate guidelines for the protection of benthic macroinvertebrate populations?

- Measure of Effect: Compare sediment concentrations to available sediment benchmarks and/or data from sediment toxicology literature.

Assessment endpoint #2: Soil invertebrate and plant communities exposed to surface soil, which are a forage resource for wildlife populations.

- Question 2-1: Do measured concentrations of analytes in surface soil exceed appropriate criteria and/or guidelines for the protection of soil invertebrates and plant, with special consideration of reproduction and early life stage survival?

- Measure of Effect: Compare surface soil concentrations to available soil benchmarks and/or data from soil toxicology literature.

Assessment Endpoint #3: Insectivorous and herbivorous mammal and bird populations exposed to soil.

- Question 3-1: Do estimated ingestion doses to insectivorous wildlife (such as shrew, meadow vole, American woodcock, American robin, etc.) exceed toxicity reference values (TRVs) for adverse effects on survival, growth or reproduction?

- Measure of Effect: Compare soil concentrations to calculated concentrations in food items that are not expected to cause adverse impacts to insectivorous or herbivorous wildlife that ingest the food items associated with soil. An assumption that the contaminant concentrations in the soil are equal to the contaminant concentrations in the food items is discussed in the uncertainty analysis section of this report.

2.5.3 Ecological Exposure Assessment

This portion of the SERA includes identification of contaminant concentration data used to represent ecological exposure in various media, and the selection of exposure point concentrations from the data. For each exposure pathway selected for quantitative evaluation, concentrations at the exposure point were estimated and the receptor-specific exposure were quantified. Exposure point concentrations were estimated using environmental sampling data. Maximum concentrations were used to assess risk in each case.

This section describes the potential or actual contact or co-occurrence of the contaminants with the receptors to determine their exposure. As discussed earlier in this report, soil, surface water, and sediment samples were collected. Only surface soil samples were used to estimate ecological risk from soil exposure, exposure occurs near the surface. For most of the areas, surface soil samples were taken from fill materials covering highly contaminated sludge deposits. Sediment and surface water samples were taken only from Area 1, the open lagoon.

2.5.4 Ecological Effects Assessment

In this step, the toxicity of the contaminants to terrestrial and aquatic organisms is characterized using screening values. The following sections discuss the sources of the screening values, and why they were selected as the screening values.

Soil

COPCs in soil pose potential risks to terrestrial invertebrates, plants, and wildlife; they were selected by comparing the maximum contaminant concentrations in the surface soil to screening values (Table 2-31). The following text discusses the screening values that were selected for each receptor. Note that the lowest screening value across all of the receptors was used for the selection of COPCs.

Invertebrates

Screening values for invertebrates were obtained from the Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson R.A. et al., 1997a). These benchmarks were intended to be used as screening values, and as such, may be overly conservative. They are based on a 20 percent reduction in growth, reproduction, or activity of invertebrates (Efroymson R.A. et al., 1997a).

Plants

Screening values for plants were obtained from the ORNL Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision

(Efroymson R.A. et al., 1997b). They are based on a 20 percent reduction in growth or yield for plants as the threshold for significant effects (Efroymson R.A. et al., 1997b).

The following study was used to obtain toxicity data for contaminants that were not included in the ORNL document: "Phytotoxicity Studies with Lactuca Sativa in Soil and Nutrient Solution" (Hulzebos et al., 1993). The study developed median effects concentrations (EC50s) for growth.

Terrestrial Wildlife

Screening values for wildlife were obtained from two ORNL documents, Preliminary Remediation Goals for Ecological Endpoints (Efroymson, et al., 1997c) and Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al., 1996). ORNL developed preliminary remediation goals (PRGs) for soil based on the lowest benchmarks among data for terrestrial plants, soil invertebrates, and wildlife. The candidate PRGs for wildlife were based on toxicity data in Sample et al. (1996), together with food chain modeling using empirical accumulation factors. These PRGs are listed in Table 2-31. Table 2-31 also lists contaminant concentrations in food items (Sample et al., 1996) that are not expected to adversely affect wildlife that ingest the food. Using these food concentrations as candidate screening levels for soil assumes that soil contaminant concentrations are equivalent to prey contaminant concentrations (accumulation factors for soil-to-prey are one). The uncertainty associated with this assumption is discussed in Section 2.5.6; the assumption will tend to overestimate the exposure for some contaminants and underestimate it for others. Because of this uncertainty, when both food-based benchmarks and PRGs for wildlife were available, the wildlife PRGs were used preferentially (Table 2-31).

The screening values for 2,3,7,8-TCDD and several other dioxins were obtained from Sample et al., (1996). The screening values for the remaining dioxins were calculated using the TEFs in the “Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife” (Van den Berg et al., 1998) (Table 2-31). The TEFs for mammals were used because the value for 2,3,7,8-TCDD obtained from Sample et al., (1996) was based on a mammal study.

Surface Water

The first choice for screening values selected to protect aquatic receptors (i.e., fish, invertebrates) were the most recent version of the Water Quality Criteria (WQC) developed by EPA (USEPA, 1999). These WQC are expected to protect 95 percent of the exposed species from mortality, reproductive effects, and other adverse effects. The chronic WQC were used, when available.

When WQC were not available, chronic values from the Toxicological Benchmarks for Screening Potential Constituents of Concern for Effects on Aquatic Biota:1996 Revision (Suter and Tsao 1996) were used. The Suter and Tsao (1996) benchmarks were calculated using Tier II methodology as described in the Proposed Water Quality Guidance for the Great Lakes System (USEPA, 1993a). Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for the EPA AWQC.

Sediment

COPCs in sediment based on potential risks to aquatic receptors (i.e., fish, benthic invertebrates) and semi-aquatic wildlife (i.e., mink, kingfishers) were selected by comparing the contaminant concentrations in the sediment to various screening values (Table 2-32). The following text discusses the screening values that were selected for each receptor. The lowest screening value across all of the receptors was used for the selection of COPCs.

Aquatic Receptors: The first choice for screening values selected to protect aquatic receptors (i.e., fish, invertebrates) were the draft USEPA Sediment Quality Criteria (SQC) that have been established for dieldrin and endrin (USEPA, 1993b and 1993c). The draft SQC for the three PAHs were not used because EPA had indicated that they would be withdrawn in favor of a total PAH SQC document (Riley, 1999).

The second choice for screening values selected to protect aquatic receptors was the Effects Range-Low (ER-L) value from the “Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments” (Long et al., 1995). These values are generally accepted by many state agencies and EPA regions, even though they are based primarily on estuarine and marine studies. The ER-L is defined as the minimal-effects range that is a concentration below which adverse effects would be rarely observed.

The Lowest Effects Level (LEL) from the “Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario” (OMOE, 1993) were used for contaminants that did not have ER-Ls. The LELs are based on freshwater studies and are defined as concentrations where sediment is considered marginally polluted but will not affect the majority of sediment-dwelling organisms.

Sediment quality benchmarks calculated for the Ecotox Thresholds (USEPA, 1996) were used for contaminants that did not have any of the above screening values. These benchmarks were calculated using equilibrium partitioning and assuming a total organic carbon concentration of 1 percent.

For some of the remaining contaminants, equilibrium partitioning or a complementary technique, was used to develop sediment screening levels. EPA’s (1993d) equilibrium partitioning (EqP) approach was used for some of the organic compounds in sediment, based on the formula:

$$WQG \text{ X } K_{oc} = SQG_{EP}$$

Where WQG = water quality guideline, mg/L

K_{oc} = organic carbon–water partition coefficient
SQG_{EP} = sediment quality guideline from EqP, mg/kg organic carbon in sediment

The equation indicates that the sediment guideline is based on the water quality guideline as an equilibrium concentration in the pore water of the sediment. As K_{oc} increases, less of the contaminant is dissolved in the pore water (more is associated with the solid phase) and the SQC_{EP} increases. K_{oc} was derived from the octanol-water partition coefficient (K_{ow}) using EPA’s formula:

$$LOG_{10}K_{oc} = 0.00028+0.983*LOG_{10}(K_{ow}), \text{ or}$$

$$K_{oc} = 10^{0.00028+0.983*LOG10(Kow)}$$

The SQG_{EP} was expressed on a (dry) bulk sediment basis with a default fraction of organic carbon in sediment (.01, or 1 percent) because there are no organic carbon data for the site:

$$SQG_{EP}\ (mg/kg) = SQG_{EP}\ (mg/kg\ OC)\ X\ 0.01$$

EqP has been applied by the EPA to organochlorine pesticides and PAHs, but not to the compounds from Mohawk Tannery in Table 2-33. The EqP model was designed for nonionic organic compounds and it may produce less reliable results as the K_{ow} values for organic compounds decrease or as polarity increases. Bioaccumulation can be predicted from K_{ow} when $\log_{10}K_{ow}$ is between 2 and 6 (USEPA, 2000a), indicating that there is less confidence in predicting bioavailability at $\log_{10}K_{ow}$ values less than 2. Several of the compounds in Table 2-33 are characterized by low K_{ow} values. Therefore, a check was performed on the EqP results. The check was done using the complementary approach, an extension of EqP theory. As K_{ow} gets lower, more of the organic compound is expected to be in the pore water. For a compound with a very low K_{ow}, such as acetone, it may be reasonable to assume that all of the compound is in pore water. Following the logic of the EqP approach, this is a conservative assumption. If the fraction of water in the wet sediment is known, the mass of material in the pore water at the WQG can be assigned to the solid fraction (water-to-sediment assignation), as explained below.

The average fraction of solids in sediments sampled for Area 1 is 0.257. Therefore, the average fraction of water is 1 - 0.257 = 0.743. Because the specific gravity of water is one, the volume of water in a kg of Area 1 sediment will be:

$$0.743\ kg\ /\ 1\ kg/L = 0.743\ L$$

The total mass of contaminant in a kg of sediment at the water quality guideline is:

$$\text{Contaminant mass (mg)} = \text{WQG (mg/L)} \times 0.743\ L$$

This mass, when divided by the mass of solid material, 0.257 kg, becomes a dry sediment concentration of:

$$SQG_{w\text{-}s}\ (mg/kg) = \text{Contaminant mass (mg)}\ /\ 0.257\ kg$$

Therefore, the SQG_{w-s} for sediment is equivalent to 0.743 / 0.257, or 2.89 times the guideline for surface water, as long as equivalent units are maintained.

The SQGs derived using both approaches are compared in Table 2-33. The SQG_{w-s} values vary directly with WQGs, at 2.89 times the WQG. The SQG_{EP} values change with K_{ow} as well as WQG. For the compound (pentachlorophenol) with $\log_{10}K_{ow}$ greater than or equal to 2, the effect of K_{ow} is to increase the SQG_{EP} relative to the SQG_{w-s}. This is expected from EqP theory, because a higher K_{ow} increases the fraction associated with the solid phase. This allows a higher SQG_{EP} while, theoretically, pore water concentrations remain below the WQG. Therefore, the assumption of all the chemical being in pore water is conservative, probably over-conservative, relative to EqP for the pentachlorophenol. The SQG_{EP} value will be used for pentachlorophenol in this assessment, because its K_{ow} is within the range expected to be useful for applying EqP.

For 4-methylphenol, carbon disulfide, phenol, 2-butanone and acetone, their lower K_{ow}s have the effect of decreasing SQG_{EP} relative to the SQG_{w-s} (Table 2-33). Because the SQG_{w-s} values represent a most conservative case in terms of the amount of chemical in porewater, the appropriateness of the SQG_{EP} values for these compounds is doubtful. As stated before, the fact that EqP is designed for nonionic organic chemicals suggests that its predictive capacity may be curtailed at low values of K_{ow} ($\log_{10}K_{ow} < 2$). Because the SQG_{w-s} values are simple and conservative, they were used to assess risk to sediment-dwelling organisms from 4-methylphenol, carbon disulfide, phenol, acetone, and 2-butanone.

Finally, the screening levels for the protection of aquatic life from exposure to dioxins were taken from EPA (1993e). TEFs for fish (van den Berg, 1998) were used to adjust the value for TCDD to other dioxin and furan congeners (Table 2-32).

Semi-Aquatic Receptors: For the semi-aquatic receptors, the screening value for 2,3,7,8-TCDD was obtained from the Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin Risks to Aquatic Life and Associated Wildlife (USEPA, 1993e). The 2,3,7,8-TCDD sediment concentration associated with low risk to mammals was selected as the screening value. The screening values for furans and the other dioxins were calculated using the TEFs for mammals in the “Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife” (Van den Berg et al., 1998).

For the other contaminants, the screening values for semi-aquatic receptors are the same as those for terrestrial receptors based on contaminant concentrations in food, as obtained from the ORNL document: Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al., 1996). The lowest acceptable concentration in the food items was used to select COPCs with the assumption that the concentration in the food item is equal to the concentration in the sediment. As is discussed in the uncertainty analysis section, this assumption will tend to overestimate the exposure for some contaminants and underestimate it for others.

2.5.5 Ecological Risk Characterization

The risk characterization is the comparison of exposure estimates to ecological effects values. It is at this step of the SERA that the likelihood of adverse effects occurring as a result of exposure to a stressor will be evaluated. A Hazard Quotient (HQ) approach was used to characterize the risk to ecological receptors.

The HQ is the ratio of the exposure point concentration to its benchmark value; when it exceeds 1.0, adverse impacts are possible. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a benchmark. A HQ value greater than 1.0 indicates that ecological receptors are potentially at risk and additional evaluation or data may be necessary to confirm whether ecological receptors are actually at risk, especially because most benchmarks are conservative. The maximum soil, sediment, and surface water concentrations were compared to screening values using the following equations:

$$HQ = \frac{Cc}{\text{Screening Value}}$$

Where: HQ = Hazard Quotient, (unitless)

C_C = Maximum contaminant concentration in soil, sediment, or surface water

Contaminants with HQs greater that 1.0 are retained as contaminants of potential concern (COPCs) for further evaluation because they have a potential to cause risk. Calcium, magnesium, potassium, and sodium were not retained as COPCs in any medium because of their relatively low toxicity to ecological receptors, and their high natural variability in concentrations. Contaminants without screening values are retained as COPCs but are only evaluated qualitatively. The following sections present the contaminants that were retained as COPCs in each of the media.

Soil HQs

Among Areas 2 through 7, maximum concentrations of bis(2-ethylhexyl)phthalate, DDE, DDT, 12 dioxin/furans, aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, vanadium, and zinc exceeded screening levels and became COPCs (Table 2-28). 1,2-Dichlorobenzene, methyl acetate, and sulfide were retained as COPCs because they had no screening levels. HQs indicating potential risk were low (<10) for bis(2-ethylhexyl)phthalate, DDE, DDT, seven dioxins/furans, arsenic, barium, cadmium, copper, and manganese. Four dioxin/furans, lead, vanadium, and zinc had moderate HQs ($10 \leq HQ < 100$), while one dioxin (HQ = 298), aluminum (HQ = 1741), antimony (HQ = 179), chromium (HQ = 528), iron (HQ = 200), and mercury (HQ = 8823) had HQs greater than 100. Of the COPCs with the highest HQs, aluminum and iron are typically not considered to be bioavailable, unless pH values are unusually low. Also, antimony and mercury are not directly associated with site tanning processes, and mercury has a screening value that is unusually low. Therefore, risks posed by dioxin and chromium appear to be of greatest concern in surface soil.

Maximum detected concentrations of the COPCs in surface soil pose a potential risk to soil invertebrates, plant communities, and insectivorous and herbivorous mammal and bird populations (Assessment Endpoints 2 and 3).

Sediment HQs

The sediment in Area 1 had 44 COPCs, of which 40 were greater than their screening levels and 4 had no screening levels (Table 2-29). In each chemical group, most of the detected chemicals became COPCs in sediment.

The maximum HQ (about 35,000) was associated 4-methylphenol. Chromium had the next highest HQ at about 30,400 and carbon disulfide (HQ = 2,293) was third highest.

HQs were low for VOCs other than carbon disulfide, but HQs for phenolics other than 4-methylphenol included 36 for pentachlorophenol and 72 for phenol. Pesticide HQs were generally low in sediment, and no PCBs were detected. The maximum dioxin/furan HQ was 218, while the highest metal HQ, other than chromium and aluminum, was 64 for lead. Phenolics, particularly 4-methylphenol, and chromium are associated with site tanning processes and have the highest potential risk levels in sediment.

Maximum detected concentrations of the COPCs in sediment pose a potential risk to aquatic invertebrate communities which are a forage resource for fish and wildlife (Assessment endpoint 1).

Surface Water HQs

Based on detected levels in two samples from Area 1, surface water COPCs were carbon disulfide, 4-methylphenol, pyrene, chromium, manganese, and selenium (Table 2-30). Manganese had the highest HQ at about 42, followed by carbon disulfide at 5.4. 4-Methylphenol and pyrene became COPCs because they had no screening levels.

Maximum detected concentrations of the COPCs in surface water pose a potential risk to aquatic invertebrate communities which are a forage resource for fish and wildlife (Assessment endpoint #1).

2.5.6 Ecological Risk Uncertainty Analysis

This section presents some of the uncertainties associated with ecological risk assessments. In this step risk levels are evaluated for possible over- or under-estimates.

2.5.6.1 Assessment Endpoints and Measures of Effects

Measures of effects are used to evaluate the assessment endpoints for the SERA. For this SERA, the measures of effects are not the same as the assessment endpoints. The measures used to predict effects are the lowest appropriate screening level. While a conservative choice, it is uncertain how the screening levels relate to the assessment endpoints.

Several endpoints were not quantitatively evaluated in this SERA. For example, risks to reptiles and amphibians were not quantitatively evaluated because exposure factors are not established for most species, and toxicity data are very limited. Therefore, potential risks to these species are not known.

2.5.6.2 Ecological Exposure Assessment

The food benchmarks presented in Sample et al., (1996) were generated by calculating contaminant doses to terrestrial wildlife using equations that incorporate ingestion rates, body weights, bioaccumulation factors, and other exposure factors. These exposure factors were obtained from literature studies or predicted using allometric equations. All of the factors vary within and among species, and from place to place, creating uncertainty in the food benchmarks.

Most of the screening values for terrestrial and semi-aquatic wildlife (i.e., mammals, birds) do not account for preferential uptake of contaminants in the food items (plants, invertebrates, fish). In other words, they simply assume the contaminant concentrations in the food items are the same as the contaminant concentrations in the substrate. For example, contaminant concentrations in soil invertebrates are assumed to be equal to the contaminant concentration in the soil. Exceptions to this are the ORNL wildlife PRGs and the TCDD sediment screening value for semi-aquatic receptors, which are based on estimated bioaccumulation through the food chain.

The application of uptake factors is not expected to substantially change the status of COPCs with high HQs. However, the following text describes how HQs based on wildlife screening levels may be affected by the application of uptake factors in each medium. A more detailed discussion of the uptake factors is presented in Section 2.5.2.2. Recall that many screening levels are based on plant or invertebrate screening levels; these would not change based on the use of uptake factors.

As indicated above, an uptake factor was applied to the TCDD screening value for semi-aquatic receptors, so the HQs calculated based on that screening value through the application of TEFs would not change. Because the 90th percentile soil-to-invertebrate factor for dioxins is above 1.0, the HQs for dioxins in surface soil would increase if uptake factors were used.

Most of the inorganics do not have 90th percentile soil-to-invertebrate uptake factors that are greater than 1.0 after accounting for wet weight of the invertebrate. That is why ORNL PRGs for wildlife tended to be higher than wildlife screening values in food (Table 2-31). Cadmium, mercury, and zinc had 90th percentile uptake factors that were greater than 1.0; each of these had ORNL PRGs that were used as candidate screening levels. Therefore, the HQs for some of the metals soil would decrease if uptake factors were used.

Soil-to-invertebrate uptake factors have not been developed for the SVOCs, although a table in Beyer (1990) indicates the factors would be less than 1.0. Other sources indicate that soil-to-plant uptake factors are expected to be less than 1.0 (ORNL, 2000). Therefore, SVOC HQs in soil would decrease if uptake factors were used. However, because no uptake factors have been developed for invertebrates, a screening evaluation would typically use a default value of 1.0. The biota-to-sediment accumulation factor (BSAF) for SVOCs requires the percentage of organic carbon in the sediment along with the percentage of lipids in the food item. Therefore, the effect of BSAF use on SVOC HQs is unknown.

Soil-to-invertebrate uptake factors have not been developed for the pesticides, although based on their high K_{ow} values, they would be expected to bioaccumulate in invertebrates. Because of their high K_{ow} values, they are not expected to bioaccumulate in plants (ORNL, 2000). Therefore, the pesticide HQs for soil would increase if uptake factors were used. The biota-to-sediment accumulation factor (BSAF) for pesticides reported in USEPA (1997b) range from 1.67 to 7.7. Although the lack of organic carbon data hampers an estimate, it is likely that HQs for pesticides in sediment would increase if BSAFs were used.

PCBs have 90th percentile soil-to-invertebrate uptake factors that are greater than 1.0 after accounting for wet weight of the invertebrate (Sample et. al., 1998). Because of their high K_{ow} values, PCBs are not expected to bioaccumulate in plants (ORNL, 2000). Therefore, the PCB HQs for soil would increase if uptake factors were used. The biota-to-sediment accumulation factor (BSAF) for PCBs reported in USEPA (1997c) is 1.85. Because of the lack of organic carbon data, it is unclear what effect BSAF use would have on PCB HQs for sediment.

There is uncertainty in the chemical data that are collected at the site. Measured levels of chemicals are only estimates of the true site chemical concentrations. For samples that are deliberately biased toward known or suspected high concentrations, predicted doses probably will be higher than actual doses.

Finally, the maximum concentrations are used in this screening evaluation. Very few receptors are exposed to the maximum concentrations for all (or even most) of the time. Using the maximum concentration overestimates risk. Most of the screening values that were used in this evaluation are based on food-chain modeling. Because the wildlife receptors will move across the site, average contaminant concentrations better represent their actual exposure.

2.5.6.3 Ecological Effects Data Assessment

There is uncertainty in the ecological toxicity values. The water quality criteria developed by USEPA in theory protects 95 percent of exposed species. Therefore, some sensitive species may be present at the site that are not protected by the use of these criteria. There also may be situations where the surface water screening values are over-protective, if the sensitive species used to develop the criteria do not inhabit the site. Finally, with the exception of hardness for a few metals and pH for pentachlorophenol, the screening values do not account for site-specific factors, such as total organic carbon or ionic strength, which may affect toxicity.

Potential adverse impacts to aquatic receptors from constituents in the sediment are evaluated by comparing the COPC concentration to sediment screening values. There are more uncertainties associated with sediment screening values than with surface water screening values for the following reasons: The procedures for developing sediment screening values are not as well established, so screening levels have been developed using different methodologies, and there are fewer sediment toxicity data than surface water toxicity data. Sediment characteristics (i.e., pH, grain size, and total organic carbon) also will have a large impact on the bioavailability and toxicity of constituents.

Potential adverse impacts to terrestrial plants and invertebrates from constituents in the surface soil are evaluated by comparing the COPC concentration to surface soil screening values. The surface soil screening values are similar to the sediment screening values in that they are less established than the surface water screening values. Fewer studies and fewer data are available for establishing surface soil screening values and many of the screening values are based on the results of only a few studies. In addition, the surface soil screening values are based on different endpoints, depending on the preference of the agency that developed them. Therefore, they have more uncertainty than surface water and sediment screening values.

The no observed adverse effects levels (NOAELs) that were selected for the wildlife endpoint species were based on species other than the endpoint species (i.e., rats, mice, ducks). There is uncertainty in the application of toxicity data across species because the contaminant may be more or less toxic to the endpoint species than it was to the test study species.

Much of the toxicity data used to develop screening values and NOAELs are based on bioavailable forms of the contaminants. For example, many of the soil screening values for invertebrates are based on soluble salts being added to the soil. Also, studies used to develop the NOAELs typically use a very bioavailable form of a contaminant to ensure that it is absorbed by the animal. Because contaminants in soil, sediment, and even surface water are typically less bioavailable than they are in the chemical forms used in toxicity tests, many of the screening values tend to be lower than what would be expected to actually cause risks to most species in the environment.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals because of synergistic or antagonistic effects.

Finally, toxicological data for a few of the COPCs are limited or do not exist. Therefore, there is uncertainty in any conclusions involving the potential impacts to ecological receptors from these constituents.

2.5.6.4 Risk Characterization

Risks are projected if an HQ is greater than or equal to unity regardless of the magnitude of the HQ. Although the relationship between the magnitude of an HQ and toxicity is not necessarily linear, the magnitude of an HQ can be used as rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used. Finally, there is uncertainty in how the predicted risks to a species at the site translate into risk to the population in the area as a whole.

2.5.6.5 Risk From Background Conditions

Background data was not collected for the Mohawk Tannery site. Therefore, it is uncertain how much of the potential risk from metals may be based on local background. However, a comparison of maximum metals concentrations found in Areas 2 through 7 surface soil, with statewide background metals concentrations in the NH RCMP reveals that the maximum metals concentrations in site surface soils generally exceeded the RCMP background concentrations by a considerable amount (at least one order of magnitude). Although RCMP background concentrations would result in HQs exceeding 1.0 for several metals (antimony 6.61, arsenic 1.1, chromium 3.30, lead 1.26, mercury 608, and zinc 11.53), most of the potential risk at the site appears to result from metals concentrations above the statewide background concentrations. NH RCMP background metals concentrations are presented on Table 2-34.

2.5.7 Summary and Recommendations

The following text summarizes the COPCs that were retained in each medium. Tables 2-28 through 2-30 note each of the contaminants that were retained as COPCs.

Surface Soil (Areas 2 – 7)

- Two VOCs
- Bis(2-ethylhexyl)phthalate
- Two Pesticides
- 12 Individual Dioxins
- 14 Inorganic Compound or Metals

Sediment (Area 1)

- Three VOCs
- Five SVOCs
- Eight Pesticides
- 14 Individual Dioxins
- 13 Inorganic Compound or Metals

Surface Water (Area 1)

- One VOC
- Two SVOCs
- Three Metals

As seen from the above list, multiple contaminants from each contaminant class (i.e., dioxins, metals, SVOCs, etc.) were retained as COPCs in surface soil and sediment. As indicated earlier in this SERA, the screening values are very conservative (i.e., they over-estimate ecological risk). They are intended to be used as screening tools to ensure that contaminants that are detected at concentrations below the screening values are not posing a risk to ecological receptors. Therefore, contaminants that are detected at concentrations above the screening values do not necessarily pose a risk to ecological receptors. There are a lot of factors that influence toxicity of the contaminants, many of which were discussed in the uncertainty analysis section. Also, the screening was conducted using the maximum concentrations while most of the ecological receptors will not be exposed to the maximum concentrations 100 percent of the time.

While conservative, the results show some areas of real concern. Risks posed by dioxin and chromium are of greatest concern in surface soil. Phenolic compounds (particularly 4-methylphenol) and chromium have the highest potential risk levels in sediment (submerged sludge in Area 1).

Also, the presence of buried sludge is a concern for the future, even though fill material currently prevents most ecological exposure. A catastrophic event, or future land use changes, may allow exposure to the sludge in areas currently covered by fill. The high risk levels in the sediment of Area 1 indicate the potential toxicity of the sludge in other disposal areas.

Although the magnitude of the HQ may not accurately indicate the magnitude of risk, the very large HQs for many COPCs indicates that additional investigations should be considered to more accurately estimate potential risks.

The following recommendations are made for consideration as part of any future ecological risk assessment work that might be completed as part of the site-wide remedial investigation.

- Re-evaluate the data in a Baseline Ecological Risk Assessment that assesses the exposure of specific receptor species occurring on site using average and maximum contaminant concentrations, where appropriate.

- Conduct appropriate toxicity tests and biological sampling to determine if adverse effects or exposures are occurring to ecological receptors and to aid in the development of cleanup levels, if necessary.

- If there is insufficient time to perform further evaluation of ecological risk, the results suggest that removal of tannery-related sludge is justified.

3.0 NON-TIME-CRITICAL REMOVAL ACTION OBJECTIVES

This section describes the regulatory basis for conducting a NTCRA to address tannery sludge and waste at the site, identifies contaminants of concern for the site, presents proposed preliminary remediation goals for the sludge and soil, and presents the overall goals and objectives of the proposed NTCRA. It also identifies potential federal and state regulations with which the selected removal action must comply, and identifies the statutory limits of removal actions. A proposed NTCRA schedule is also presented in this section.

3.1 Regulatory Basis for a Removal Action

This section identifies the site conditions that provide the legal justification for conducting a NTCRA to address tannery sludge and waste at the site. These site conditions correspond to factors cited in Section 300.415(b)(2) of the NCP that provide a basis for conducting a removal action:

- *40 CFR 300.415(b)(2)(i): Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants:* Potential threats to human and ecological receptors exist through potential current and future direct exposures to contaminants present in surface and subsurface materials at the site. The streamlined human health risk evaluation identified non-cancer health threats for current trespasser exposure to sludge in the Area 1 lagoon (HI=42.5), future residential exposure to surface soil and sludge in disposal areas 2 through 7 (HI=13.1), and future residential exposure to surface and subsurface soil and sludge (0 to 10 feet bgs) in all seven disposal areas (HI=72.4). The human health risk evaluation also identified cancer risks in excess of 1.0E-04 for current trespasser exposure to sludge in the Area 1 lagoon (1.86E-03) and future residential exposure to surface and subsurface soil and sludge (0 to 10 feet bgs) in all seven disposal areas (1.87E-04). The streamlined ecological risk evaluation identified potential risks to ecological receptors from contact with sludge/sediment in the Area 1 lagoon and surface soil in Areas 2 through 7. Ecological risks posed by 4-methyphenol and chromium are of greatest concern in sludge/sediment and risks posed by dioxins and chromium are of greatest concern in surface soil.

- *40 CFR 300.415(b)(2)(ii): Actual or potential contamination of drinking water supplies or sensitive ecosystems:* Significant quantities of contaminated tannery sludge/waste are located beneath the water table in a number of the disposal areas at the site including the two largest disposal lagoons, Area 1 and Area 2. Based on October 2001 groundwater conditions as much as 6 feet and 9 feet of the sludge in Areas 1 and 2 respectively, are buried below the water table. The presence of contaminated sludge below the water table and the usage of the groundwater as a drinking water supply for populations nearby the site provides the potential for contamination of an important drinking water supply. In addition, for many years sludge/waste from the site was discharged directly into the Nashua River thereby potentially impacting this important and sensitive ecosystem. The impacts of the sludge/waste on the groundwater as well as the Nashua River will be addressed as part of the ensuing site-wide remedial investigation.

- *40 CFR 300.415(b)(2)(iv): High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate:* Contaminated tannery sludge/waste is present at the surface throughout Area 1, and at some locations in Areas 6, and 7. Analysis of sludge/waste samples collected from these areas revealed the presence of several contaminants at concentrations exceeding screening criteria. The surface contamination in Areas 6 and 7 may migrate via precipitation runoff and through leaching into the groundwater. Under both scenarios, contamination would likely end up discharging into and impacting the nearby Nashua River. Disposal Area 1 is located immediately adjacent to the Nashua River. The Area 1 open lagoon is surrounded by an earthen berm that is higher than the 100-year flood elevation. However, the sludge elevation in the lagoon is below the 100-year flood elevation. If the berm was breached by a major storm or flood event, a significant washout of highly contaminated sludge into the Nashua River and its floodplain could occur.

- *40 CFR 300.415(b)(2)(v): Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released:* Disposal Areas 1 and 2 are located immediately adjacent to the Nashua River. Most of Area 2 is situated in the 100-year floodplain of the Nashua River. Inundation of Area 2 with floodwaters could result in washout of the cover soils and mobilization of contaminated sludge/waste into the Nashua River and its floodplain. Additionally, a major storm event could cause a washout of sludge/waste in Area 1 into the Nashua River and its floodplain, as described above.

Based upon these factors, a potential threat exists to public health or welfare or the environment that justifies conducting an NTCRA to address the tannery waste in the seven disposal areas at the site. In particular, a removal action is necessary to prevent contact with and control and contain the release of hazardous substances from the site through source control measures. This removal action is designated as non-time critical because more than 6 months' planning time is available before on-site activities must be initiated. As a result, the completion of an Engineering Evaluation/Cost Analysis (EE/CA) is required pursuant to 40 CFR Section 300.415(b)(4)(i).

3.2 Selection of Contaminants of Concern

Using analytical results from the EE/CA field investigation and the results of the streamlined human health risk evaluation, contaminants of concern (COCs) that pose threats to human health were identified. No COCs were developed for protection of ecological receptors because the streamlined ecological risk evaluation was a screening-level, qualitative evaluation only and therefore could not be used to definitively identify COCs. The streamlined ecological risk evaluation identified numerous chemicals of potential concern to ecological receptors at the site and concluded that additional investigations should be considered to more accurately estimate potential risks. A comprehensive, quantitative ecological risk assessment may be performed as part of the comprehensive Remedial Investigation/Feasibility Study (RI/FS) for the site that is to be initiated later this year.

The COCs identified for the site are compounds that posed an excess carcinogenic risk greater that 1.0E-6 or an excess non-carcinogenic risk indicated by a hazard index greater than 1 for any exposure scenario. The COCs identified for the site are identified on the table below.

Contaminants of Concern	Cancer Risk > 1.0E-6	Non-Cancer HI >1.0
Benzo(a)Pyrene	X	
Pentachlorophenol	X	
4-Methylphenol		X
Dioxin TEQ	X	
Antimony		X
Arsenic	X	X
Barium		X
Cadmium		X
Chromium		X
Manganese		X
Vanadium		X

3.3 Identification of Preliminary Remediation Goals (PRGs)

Preliminary Remediation Goals (PRGs) are the numerical chemical concentrations in environmental media that would not cause excess health risks to humans or the environment. Protection of human health and the environment can be achieved by treating, removing, containing, or preventing exposure to environmental media containing contaminants above these PRGs. PRGs may be selected from a combination of risk-based values developed for the site, regulatory standards, available guidance or screening criteria.

PRGs for site sludge/waste and soil were developed using risk-based values calculated from exposure scenarios identified in the streamlined human health risk evaluation; available guidance for addressing dioxin contamination: EPA OSWER Directive 9200.4-26, Approach to Addressing Dioxins in Soil at CERCLA and RCRA Sites (USEPA, 1998a); and the NHDES RCMP background concentrations of metals in soils. NHDES RCMP Method 1 Soil standards were considered, but not used in selection of the proposed PRGs because the Method 1 standards are non-promulgated criteria used as default standards in absence of a site-specific risk assessment. Because a comprehensive risk evaluation was performed for site soil/sludge, the risk-based PRGs calculated for the site were used in place of the Method 1 standards. There are no other applicable or relevant and appropriate regulatory standards for soil/sludge. Risk-based PRGs were not developed for protection of ecological receptors because the streamlined ecological risk evaluation was qualitative in scope and could not be used to quantitatively determine PRGs.

Potential PRGs representing human cancer risk levels of 1.0E-6, 1.0E-5, and 1.0E-4 and non-cancer hazard indexes of 0.1 and 1.0 were calculated for each COC identified in Section 3.2 to provide risk managers with a range of options for reducing human health risks at the site. The risk-based PRGs were calculated using the exposure assumptions developed for residential exposure to site soil/sludge. The residential exposure scenario is more conservative than the scenario that considers current trespasser exposure to surface soil/sludge in Areas 2 through 7, but less conservative than the scenario for current trespasser exposure to wet sludge in Area 1. As a result, the PRGs calculated for the residential scenario are protective for future residents as well as current trespassers exposed to surface soil/sludge. Although lower PRGs could be calculated for the wet sludge in Area 1 based on the exposure assumptions for protection of trespassers in that area, the PRGs calculated based on the residential exposure scenario are considered adequate for the site because several contaminants in the Area 1 sludge exceed the calculated PRGs and it would be completely removed under all of the NTCRA alternatives considered.

The risk-based PRGs were used along with the EPA OSWER Directive <u>Approach to Addressing Dioxins in Soil at CERCLA and RCRA Sites</u> (USEPA, 1998a) and the NH RCMP background concentrations to select proposed PRGs for each COC. For all COCs except dioxins, the proposed PRG was selected from the lower of the risk-based PRGs corresponding to a cancer risk level of 1.0E-6 and a hazard index of 1.0. If the selected risk-based PRG was lower than the NH RCMP background concentrations of metals in soil, then the background concentration was selected as the proposed PRG. For dioxins, the proposed PRG was selected based on the EPA OSWER Directive <u>Approach to Addressing Dioxins in Soil at CERCLA and RCRA Sites</u> (USEPA, 1998a). The directive recommends a cleanup level for dioxin TEQs of 1000 ng/kg for residential settings. This value is proposed for use pending completion of EPA's comprehensive reassessment of the toxicity of dioxin. Table 3-1 presents the potential and proposed PRGs for each compound.

Because the scope of the proposed NTCRA is limited to source control for contaminated soils, sludges, and wastes, PRGs were not developed for groundwater, surface water or river sediments. These media will be evaluated in the RI/FS scheduled to begin later this year.

3.4 Volume of Wastes to be Addressed in the NTCRA

As detailed in Section 2.1.3 and summarized on Table 2-20, sample analytical results were compared with the proposed PRGs to estimate the volume of sludge/waste and soil to be addressed under the NTCRA. The following table provides a summary of the estimated volume of sludge/waste in each disposal area that contains contaminants at concentrations exceeding the proposed PRGs. No visual evidence of sludge/waste was found in Area 5 and no contaminants were detected in Area 5 samples at concentrations exceeding the proposed PRGs. As a result, no sludge/waste volume was estimated for this area. Contaminant concentrations in overlying and underlying soil also did not exceed the proposed PRGs, so no sludge/waste volume was estimated for the soils.

Disposal Area	Estimated Volume of Sludge/Waste (CY)
Area 1	25,185
Area 2	29,630
Area 3	370
Area 4	1,000
Area 6	648
Area 7	3,556
TOTAL VOLUME:	60,389

3.5 Removal Action Objectives

Based on the conditions described in Section 3.1, a NTCRA is necessary to mitigate risks posed by tannery sludge/waste at the site and to stabilize conditions while long-term remedial options for the site are evaluated.

To achieve these goals, removal action objectives were developed that are protective of human health and the environment and consider potential future use of the site. These removal action objectives are presented below.

Prevent, to the extent practicable, direct contact with, ingestion of, and inhalation of contaminants in tannery sludge/waste and associated soil at concentrations exceeding PRGs.

- Prevent, to the extent practicable, ecological receptor exposure to contaminants exceeding PRGs in tannery sludge/waste and associated soil.

- Prevent, to the extent practicable, migration of contaminants exceeding PRGs from tannery sludge/waste and associated soil to site groundwater and the Nashua River.

- Address tannery sludge/waste and associated soil with contaminants exceeding PRGs to restore the site to its intended use for residential purposes.

3.6 Statutory Limits on Removal Actions

40 CFR Part 300.415(b)(5) and Section 104(c)(1) of CERCLA set limits of 12 months and 2 million dollars for fund-financed removal actions. An exemption from the time and dollar limitations in the statute can be granted in situations where EPA determines that the proposed removal action is appropriate and consistent with the anticipated long-term remedial action.

Because the NTCRA proposed in this EE/CA would be a fund-financed action, it would have to comply with these statutory limits or obtain an exemption. An exemption may be possible because the alternatives evaluated in this EE/CA are consistent with any anticipated long-term remedial action for the site. The risk-based evaluation was performed that further supports consistency between this NTCRA and any long-term remedial actions.

3.7 ARARs and TBCs

Section 300.415(j) of the NCP requires that "Fund-financed removal actions under CERCLA Section 104 and removal actions pursuant to CERCLA Section 106 shall, to the extent practicable considering the exigencies of the situation, attain applicable or relevant and appropriate requirements (ARARs) under federal environmental or state environmental or facility siting laws…Other federal and state advisories, criteria, or guidance may, as appropriate [to be considered - TBC], be considered in formulating the removal action." The NTCRA guidance states that "...only State standards that are promulgated, identified by the State in a timely manner, and more stringent than Federal requirements may be applicable or relevant and appropriate."

ARARs are promulgated, enforceable federal environmental and state environmental or facility siting requirements. There are two categories of requirements: "applicable" and "relevant and appropriate". CERCLA does not allow a regulation to be considered as both "applicable" and "relevant and appropriate". These categories are defined below:

<u>Applicable Requirements</u> - Section 300.5 of the NCP defines applicable requirements as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site".

<u>Relevant and Appropriate Requirements</u> - Section 300.5 of the NCP defines relevant and appropriate requirements as "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site."

To be considered (TBCs) guidelines are non-promulgated criteria, advisories, and guidances issued by the federal or state governments. Along with ARARs, TBCs may be used to develop the interim action limits necessary to protect human health and the environment or to guide development of the removal action source control measures, i.e., cap system conceptual design.

While ARAR requirements under CERCLA pertain only to on-site activities, off-site activities relating to hazardous waste disposal are required to meet all applicable laws including, but not limited to: Department of Transportation regulations governing the marking and labeling of hazardous materials shipments (49 CFR 192), shipping requirements (49 CFR 173), and transport of hazardous materials by motor vehicles (49 CFR 173 and 49 CFR 177); and Resource Conservation and Recovery Act (RCRA) regulations governing transporter activities and treatment, storage, and disposal facilities (40 CFR 261-264), land disposal restrictions (40 CFR 268), and off-site response actions (40 CFR 300.440); and CERCLA 121(d)(3). Other non-ARAR off-site requirements include state labeling, shipping, and transport requirements for state-designated hazardous wastes and CERCLA Section 121 (d)(3) requirements for the off-site transfer of CERCLA wastes.

The Occupational Safety and Health Administration (OSHA) regulations are not ARARs, but apply to both on- and off-site activities. These include regulations governing performance of activities at hazardous waste sites (29 CFR 1910.120), general construction guidelines (29 CFR 1926), and occupational exposure to asbestos (29 CFR 1910.1001).

ARARs, and standards and guidance to be considered are divided into three categories: chemical-specific, location-specific, and action-specific. In Sections 3.4.1 through 3.4.3, these categories are briefly described and potential ARARs and TBCs for the site are identified.

3.7.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the determination of numerical values that establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. In general, chemical-specific requirements are set for a single chemical or a closely-related group of chemicals. These requirements do not consider the mixture of chemicals. Because there are no promulgated federal or state criteria for contaminated soil or sludge, no chemical-specific ARARs were identified for the site. However, several chemical-specific TBCs were identified.

The EPA Region IX Preliminary Remediation Goals, EPA's OSWER Directive *Approach to Addressing Dioxin in Soil at CERCLA and RCRA Sites*, and the NHDES RCMP Method 1 soil standards and background concentrations of metals in soils are among the TBCs that were used in the data evaluation and human health risk evaluation to identify potential contaminants of concern and develop PRGs. A summary of potential chemical-specific ARARs and TBCs for each removal action alternative is presented with the detailed analysis of each alternative (Section 5.0).

3.7.2 Location-Specific ARARs and TBCs

Location-specific ARARs are restrictions placed on the concentrations of hazardous substances, or the conduct of activities solely because they are performed in specific areas. The general types of location-specific ARARs that may be applied to the site are briefly described below.

Several federal and state ARARs regulate activities that may be conducted in wetlands and floodplains. These regulations and requirements may apply because portions of the site are either occupied by wetlands or are situated in the 100-year floodplain. The Wetlands Executive Order (E.O. 11990) and the Floodplains Executive Order (E.O. 11988), incorporated into 40 CFR Part 6, Appendix A, require that wetlands and floodplains be protected and preserved, and that adverse impacts be minimized. Section 404 of the Clean Water Act and state wetland protection regulations restrict activities that adversely affect wetlands and waterways.

Additional location-specific ARARs include the Fish and Wildlife Coordination Act, which requires that any federal agency proposing to modify a wetland or body of water must consult with the U.S. Fish and Wildlife Service. Regulations governing endangered species at the federal and state levels would need to be considered for any proposed on-site actions, if such species are encountered. A summary of potential location-specific ARARs and TBCs for each removal action alternative is presented with the detailed analysis of each alternative (Section 5.0).

3.7.3 Action-Specific ARARs and TBCs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are generally focused on actions taken to remediate, handle, treat, transport, or dispose of hazardous wastes. These action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be implemented. The general types of action-specific ARARs that may be applied to removal actions at the site are briefly described below.

Most action-specific ARARs fall into three primary categories: federal and state regulations pertaining to the Clean Water Act (CWA), Clean Air Act (CAA), and Resource Conservation and Recovery Act (RCRA). CWA ARARs generally regulate the discharge of treated groundwater. CAA requirements typically pertain to air emissions from hazardous waste treatment operations. RCRA ARARs typically establish design, operating, and monitoring requirements for hazardous waste treatment facilities. A summary of potential action-specific ARARs and TBCs for each removal action alternative is presented with the detailed analysis of each alternative (Section 5.0).

The determination of whether RCRA regulations are applicable or relevant and appropriate is contingent on whether site sludge/waste is classified a RCRA hazardous waste. In April of 2002, the NHDES completed an updated hazardous waste determination for site sludge/waste using data gathered during the EE/CA field investigation. The data and the NHDES determination support the current assumption that sludge/waste from the site would not be considered a RCRA hazardous waste. However, based on the reactive sulfide concentrations found in Area 1 during the EE/CA investigation, it is possible that sludge/waste may be encountered in this area during implementation of the NTCRA that could be considered hazardous. Although it does not appear likely that the sludge/waste at the site will be classified as RCRA hazardous, a final decision on the regulatory status of the sludge/waste will be made during implementation of the removal action based on the results of the waste characterization samples collected from sludge/waste stockpiles during excavation.

For the purposes of identifying ARARs for removal alternatives in the EE/CA, it is assumed that sludge/waste would not be classified as a hazardous waste. Therefore several of the action-specific ARARs pertaining to hazardous wastes are considered relevant and appropriate rather than applicable. If characterization sampling and analysis performed during the removal action determines that sludge/waste must be classified as hazardous, the status of these action-specific ARARs would change to applicable.

4.0 DEVELOPMENT OF REMOVAL ACTION ALTERNATIVES

This section presents the rationale for developing removal action alternatives that address the removal action objectives (RAOs) presented in Section 3.0, and provides descriptions of the assembled removal action alternatives. The development of removal alternatives consists of identifying statutory and policy considerations, formulating a list of potential technologies and process options, evaluating the ability of technologies and process options to achieve RAOs, and assembling selected technologies and process options into removal action alternatives. The detailed evaluations of alternatives and associated costs are presented in Section 5.0.

The following subsections detail the key factors or considerations used in the formulation of potential technologies and process options and the development of removal action alternatives.

4.1 Statutory, Policy, and Other Considerations

Statutes and policies identified and reviewed to help evaluate potential technologies and formulate the range of removal action alternatives are presented in the following narrative.

4.1.1 Statutory Considerations

Removal action alternatives were developed in accordance with the NCP (40 CFR 300.415) requirements for assessing and selecting response actions. The NCP (40 CFR 300.415(c)) encourages the development of alternatives that, to the extent practicable, contribute to the efficient performance of any anticipated long-term remedial action with respect to the release concerned. The NCP (40 CFR 300.415(d)) also identifies appropriate removal actions that address risks to the public health or welfare, or the environment including:

- Establishing site control and security measures.
- Installing drainage controls to reduce or prevent contaminant migration.
- Capping to prevent contact and reduce contaminant migration.
- Using chemicals or materials to prevent or mitigate contaminant releases.

- Excavating, consolidating, or removing highly contaminated soils to reduce direct contact with or spread of contamination.
- Containing, treating, disposing, or incinerating hazardous materials.

Section 121(b) under CERCLA (and amendments) expresses the preference for treatment over conventional containment or land disposal to address a principal threat at a site. This preference for treatment appears to apply to remedial actions, but the overall philosophy is also appropriate for removal actions. Where viable, the preference for treatment over disposal will be considered for this EE/CA.

4.1.2 Policy, Guidance, and Other Considerations

The Superfund Accelerated Cleanup Model (SACM) policy is a process change for all Superfund activities, consistent with the NCP and CERCLA, to take early actions that achieve prompt risk reduction and increase the overall efficiency of site responses. Early actions at the site to address contaminated sludge/waste would prevent potential human and ecological direct exposures and mitigate excessive health risks. Early actions would also prevent further contaminated media transport during flood occurrences. Consideration for early action will be given during the development of removal action alternatives.

4.1.3 Hazardous Waste Determination Considerations

As noted in Section 3.7.3, based on site data and an April 2002 hazardous waste determination for site sludge/waste completed by NHDES, it does not appear likely that the sludge/waste at the site will be classified as RCRA hazardous. However, based on the reactive sulfide concentrations found in Area 1 during the EE/CA investigation, it is possible that sludge/waste may be encountered in Area 1 during implementation of the NTCRA that could cause the material be considered hazardous.

The RCRA classification of the sludge/waste could have considerable impacts on the implementability and cost of the removal action. A hazardous waste determination would require that sludge/waste be disposed of at a RCRA Subtitle C landfill, and could potentially make applicable RCRA land disposal standards for dioxin-containing material as defined in 40

CFR 268.31. As a result, scenarios under which the material from Area 1 would be considered a RCRA hazardous waste were included in the EE/CA. The final determination of the regulatory status of the sludge/waste will be made based on the results of the waste characterization samples collected from sludge/waste stockpiles during implementation of the removal action.

4.1.4 Floodplain Considerations

As depicted on Figure 1-3, part of Area 2 resides within the 100-year floodplain. The base flood elevation is approximately 131 feet above MSL along the Nashua River at the west end of the site. The Area 1 open lagoon is not located within the 100-year floodplain due to the elevation of the manmade soil berm located along its perimeter; however the top of the sludge in the lagoon is below the 100-year floodplain. If the berm were to be breached, the Area 1 lagoon would also be located within the 100-year floodplain.

The floodplains and the flood storage capacity of the site will be considered in the development of removal action alternatives. Executive Order 11988 requires that remedial alternatives be evaluated to avoid the effects of incompatible development in floodplains, and to minimize potential harm to floodplains if the only practicable alternative requires siting an action in a floodplain. The order also provides opportunities for public review.

For the purpose of the EE/CA, the potential impact (loss of flood storage capacity) of each alternative will be briefly evaluated, where applicable. Once a removal action alternative is selected for the site, a formal floodplains assessment, if necessary, will be completed to accurately estimate impacts to the floodplain capacity, effects of construction/excavation on the floodway, and determine whether impedances exist to flood conveyance. Based on those findings, options for developing compensatory flood storage capacity may be established.

4.1.5 Wetlands Considerations

TtNUS performed an ecological survey of the Mohawk Tannery Site during the summer of 2001, which included a wetland delineation. As described in Section 1.4.5, two wetland areas were identified onsite (see Figure 1-3). Both of the identified wetland areas are located on the undeveloped, southern parcel of the Mohawk Tannery property and are not likely to be impacted by removal actions at the site. The Area 1 open lagoon is not considered a jurisdictional wetland.

4.1.6 Considerations for Future Use of the Mohawk Tannery

The intended future use of the Mohawk Tannery site includes restoration of the property for residential purposes. One of the RAOs developed for the EE/CA addresses this objective. The alternatives evaluated under the EE/CA will consider future use of the site for residential purposes in analysis of effectiveness.

4.2 General Response Actions, Technology Types, and Process Options

General response actions were identified for the site that would address the removal action objectives. Technologies and process options corresponding to the general response actions were identified based on the nature of chemicals to be addressed; their effectiveness in reducing contaminant mobility, toxicity, and volume; and statutory and guidance considerations. Removal action objectives, general response actions, technology types, and process options that are potentially applicable to the contaminated sludge and soil at the site are presented on Table 4-1.

4.3 Screening of Technologies and Process Options

The technology types and process options identified on Table 4-1 were screened according to their potential effectiveness and implementability for treating site sludge/soil waste. The evaluation considered site-specific factors such as ability to meet removal action objectives, the nature of contaminated media, moisture content of sludge, contaminants present, location of wastes within the 100-year floodplain, and proximity to residential areas. A summary of screening results is presented on Table 4-2. Technology and process options that passed the screening are identified below:

- Off-Site Landfill
- On-Site Landfill

- Incineration (off-site)
- Stabilization (potentially applicable for treatment residuals following thermal treatment)

These technologies and process options were used to form a range of viable removal action alternatives that address the removal action objectives. The assembled alternatives provide a range of options for risk reduction through on-site and off-site containment and treatment alternatives. A description of the rationale used to assemble removal action alternatives and detailed descriptions of the identified alternatives are provided in the following sections.

4.4 Rationale for Development of Removal Action Alternatives

The screening of technologies and process options concluded that ex-situ treatment and/or disposal options were the most feasible considering the nature (contaminant type, moisture content) and extent (60,000 CY, portions located below the groundwater table) of sludge/waste observed at the site and the location of the majority of the waste (within the 100 year floodplain of the Nashua River). Therefore, excavation using common construction techniques would be part of any removal action implemented under the EE/CA.

Three alternatives were developed to provide a range of on-site and off-site containment and treatment options. Off-site landfill disposal was retained as an effective, implementable containment alternative. Disposal in a newly constructed on-site landfill was retained to provide an on-site alternative to off-site disposal. Finally, a third alternative was assembled to provide an option that would treat all the waste. This alternative is the only one that would satisfy the statutory preference for treatment. Due to the nature of contaminants and the moisture content of sludge/waste, incineration (off-site) was the selected treatment option.

4.5 Descriptions of Removal Action Alternatives

The three removal alternatives were developed by assembling the various response technologies and treatment options retained in the screening presented in Section 4.3. The alternatives are consistent with the guidelines identified in the NCP (40 CFR 300.415 (d)) and address the RAOs established for the site:

- Alternative 1 involves the excavation of contaminated sludge/waste, and transportation and disposal in an EPA-approved off-site landfill facility.

- Alternative 2 involves the excavation and consolidation of excavated sludge/waste into a lined on-site landfill designed to reduce leaching of contaminants and prevent direct exposure to contaminated sludge/waste.

- Alternative 3 involves the excavation of sludge/waste and transportation to an off-site incineration facility.

As discussed in Section 4.1.3, the regulatory classification of the sludge/waste could have considerable impacts on the implementability and cost of the removal action. As a result, each of the above alternatives was evaluated under various scenarios based on the nature and regulatory status of the sludge/waste. Based on data from the EE/CA field investigation, it is assumed that only sludge from Area 1 would be impacted by the final waste determination.

The RCRA waste status of the sludge/waste would directly impact only the off-site and on-site disposal alternatives. Therefore, Alternatives 1 and 2 were evaluated under the following three potential regulatory scenarios:

- Scenario A – All sludge/waste classified as non-hazardous
- Scenario B – Area 1 sludge classified as hazardous, land ban for dioxin-containing material not applicable
- Scenario C – Area 1 sludge classified as hazardous, land ban for dioxin-containing material applicable

Implementability and cost issues for the off-site incineration alternative are not necessarily related to regulatory status, but to the differing availability of incinerators in the United States and Canada that are able to accept dioxin-containing material. Because use of incineration facilities in the U.S. and Canada has different implementability condsiderations and costs, Alternative 3 was evaluated under the following two scenarios:

- Scenario 3-US – All sludge/waste treated and disposed at a U.S. incineration facility

- Scenario 3-CAN – All sludge/waste treated and disposed at a Canadian incineration facility

Detailed descriptions of the three alternatives are presented in the following sections. Several aspects of the removal are the same for all three alternatives. These are discussed in detail in the Alternative 1 description only. Then the variations or differences from Alternative 1 are presented in descriptions of the other two removal action alternatives.

4.5.1 Alternative 1 – Excavation and Off-Site Disposal

Alternative 1 features the excavation, transportation, and off-site disposal of contaminated sludge/waste. All sludge/waste containing concentrations of contaminants in excess of PRGs would be excavated and transported to an EPA-approved, off-site landfill facility. The estimated volume of sludge/waste requiring removal and disposal would be as presented in Section 3.4. Engineering controls would be implemented during the removal action to minimize the impact to human health and the environment during excavation. Excavated areas would be backfilled with overlying soil and/or clean common fill and revegetated.

The key features of Alternative 1 are identified on Table 4-3. The Alternative 1 site implementation layout is depicted in Figure 4-1. The following is a description of the key aspects of this alternative.

i. <u>Pre-Design Investigation (PDI)</u>

Prior to the implementation of Alternative 1, it may be necessary to conduct a PDI to verify the effectiveness and assist in the design of any sludge pre-treatment techniques that would be required to manage the high moisture content and strong sulfide odors that are characteristic of site sludge. Pre-treatment would be used to prepare excavated sludges in the stockpiling/staging area so that they will be suitable for transportation and disposal. The effectiveness of air treatment/odor control technologies may also need to be verified during the PDI. These technologies will be an integral part of the engineering controls that will be used to control sulfide odors and contaminant emissions during excavation. The objective of the PDI would be to determine the optimal reagent mixtures and volumes required to adequately control moisture and odor concerns during excavation and handling of sludge/waste.

The PDI might also include an evaluation of potential dewatering options that may be used during excavation of sludge/waste from below the water table. This evaluation may include aquifer testing to provide a basis for the estimation of recharge rates, and volume of water requiring removal, that would be expected during excavation. Groundwater samples would be collected and analyzed during the PDI to determine the need for pretreatment of dewatering effluent prior to discharge to the city sewer system.

ii. Mobilization

Field project personnel, field support services, and subcontractor personnel and equipment would be mobilized prior to the initiation of site work. Equipment and support facilities to be employed may include:

- Field office trailer, storage trailers, and sanitary facilities.
- Heavy equipment (excavator, backhoe, dump trucks, bulldozer, odor control equipment, vibratory compactor, etc.).
- Health and safety, sampling, and decontamination equipment.
- Subcontractor equipment needed for clearing and grubbing, excavation, and waste management.
- Utility extension/hook-ups (including telephone, electricity).

iii. Site Preparation

As mobilization of personnel, equipment, and materials to the site commences, site preparation activities would be implemented to prepare for the subsequent construction activities. Some of the site preparation activities, such as the installation of erosion and sedimentation controls, may occur simultaneously with mobilization activities. Erosion and sedimentation controls would be installed prior to the implementation of other site preparation activities.

Silt fences, hay bales, and other erosion control measures would be installed, as necessary, along the edges of the cleared/disturbed areas of the site, around any sludge/waste or soil stockpiles, and around the decontamination pads. A reinforced silt fence and hay bales would be placed along the Nashua River prior to any earth moving activities. Other site controls would be implemented, as necessary, to minimize impacts to the environment resulting from excavation and stockpiling activities.

Following the installation of erosion control measures, clearing and grubbing of site vegetation and demolition/removal of any obstructions would be performed to facilitate earth moving, construction of site improvements (access road, stockpiling areas), and hauling.

In order to accommodate the heavy truck traffic that would be required to haul contaminated sludge/waste off site, a site access road would be constructed to provide a direct route from the site to Broad Street and Route 3 (Figure 4-1). The proposed access road would leave the site at the existing truck gate at the north end of the site between Area 5 and the gravel pit. The road would run to the west of the Fimbel Landfill, around the Fimbel Door Company Building, and onto Broad Street less than one-half mile from Route 3. The access road would improve access to major roadways in the site vicinity, while alleviating potential short-term impacts from truck traffic through the residential neighborhoods located along the current site access route (Fairmont Street). Construction of the road would primarily involve the improvement of existing roads or rights-of-way. Pavement on the Fimbel Property would be reinforced or reinstalled, and unpaved road surfaces would be improved with compacted gravel fill.

Existing on-site roads would be graded and improved to improve access to disposal areas and facilitate loading and transportation of sludge/waste and soil throughout the site. Crushed stone and gravel would be placed, graded, and compacted to provide a suitable surface. Appropriate locations would be identified for the decontamination pads and the soil/sludge stockpiling and staging areas so that the haul road is optimally designed.

Prior to excavation activities in Area 1, the wood-frame clarifier building located to the north of the lagoon would be demolished. Demolition of this building would improve the access for excavation and hauling equipment to the northern portion of the lagoon. A reinforced concrete clarifier tank is currently located inside of the building. This tank was emptied during a time-critical removal action in late 2000, but has since been partially refilled by groundwater seepage. Evacuation and removal of the clarifier tank would be performed prior to building demolition.

iv. <u>Excavation and Backfill</u>

All sludge/waste determined to contain concentrations of contaminants exceeding PRGs (see Section 3.0) would be excavated using common construction equipment (bulldozers, scrapers, hydraulic excavators, etc.). For the EE/CA, it is estimated that approximately 60,000 cubic yards of contaminated sludge/waste would require excavation. This volume includes an estimated quantity of waste or fill that was not readily identifiable as tannery sludge, but was determined to contain contaminants in excess of PRGs. Excavated sludge/waste would be staged on-site in a predetermined stockpiling location. Overlying soil excavated from Disposal Areas 2, 3, 4, and 6 (approximately 9,500 CY) would be segregated from sludge/waste during excavation and staged in a separate stockpile area.

Prior to commencing excavation in Area 1, all surface water would be pumped from the lagoon and staged in a portable water storage tank on the site, sampled and analyzed. Contingent on the results of laboratory analysis, the surface water would be discharged to the Nashua wastewater treatment plant via the onsite sewer line. Because excavation of contaminated sludge in Areas 1 and 2 (and possibly Area 3) will likely extend below the water table into saturated sludge, excavation and removal of sludge/waste in these areas would require the design of an in-situ dewatering system. During removal of saturated sludge, standing water from the open excavation would be pumped into a fractionation tank where solids would be allowed to settle. Water from the fractionation tank would be transferred into a second tank from which samples would be collected and analyzed. Contingent on the results of laboratory analysis, dewatering effluent would be discharged to the Nashua wastewater treatment plant via the onsite sewer line. It is assumed that the surface water from the lagoon and the dewatering effluent would not require additional treatment (other than settling) prior to discharge to the sewer line.

As warranted, engineering controls would be implemented during excavation activities to prevent odors and fugitive dust emissions. Odor control technologies and other controls such as dust suppressants and water sprays would be applied as appropriate during excavation, hauling, and handling to suppress odors and dust. A conceptual design for the odor control system that would be used at the point of excavation and possibly in the sludge/waste stockpiling area is presented below. Many of the design details will have to be developed during the pre-design investigation or during implementation of the removal action, but a general description of the system was developed for the EE/CA.

Sulfide odors would be neutralized during excavation of sludge/waste through the delivery of an atomizing mist to the active excavation area. The mist would consist of a solution of potable water mixed at varying ratios (depending on the strength of the odor) with an atomizing reagent. The odor control solution would be delivered to the excavation area through a nozzle line installed at the perimeter of the active excavation area. The nozzle line would contain up to several hundred nozzles, and would be placed to optimize coverage of the area of concern.

A self-contained trailer-mounted system with a 535-gallon water tank, a mixing tank, and a diesel powered generator would likely be used to deliver the reagent solution to the nozzle line. An injection pump would be used to inject the atomizing reagent into the water flow at any desired dilution rate, so that the dilution ratios could be easily varied depending on the strength of the odors in a given area.

Due to high moisture contents observed during the EE/CA field investigation and likelihood of excavation below the water table, it is likely that an ex-situ dewatering system will be needed in the sludge/waste stockpiling area to prepare excavated media for transport and disposal. This would be accomplished through the construction of a concrete pad with water collection sumps to be used for the sludge/waste handling and stockpiling area. Free water released from excavated sludge that is collected in the sumps would be pumped into the fractionation tank, along with water generated from excavation activities below the water table. Once solids are allowed to settle and water is transferred to the storage tank, samples would be collected and analyzed. Pending the results of analysis, this water would be discharged to the onsite sewer line.

Additional moisture control measures, such as the addition of bulking agents (i.e. lime), would be taken to provide further moisture reduction during stockpile handling and maintenance, if necessary. The need for addition of bulking agents would be dependent primarily on the moisture content of sludge/waste as it is placed in the stockpile area and the moisture requirements for transport and disposal of the sludge at the landfill. Odor control is not expected to be a significant factor for transport and disposal. Therefore, if the material meets the moisture requirements for transport and disposal without lime addition, odors in the stockpile area would likely be controlled using atomizing mist to neutralize odors. The anticipated demand for lime or other bulking agents would be assessed through the performance of a pre-design investigation and/or through periodic assessment of conditions during the removal action and communication with the disposal facility during transportation and disposal.

Sludge/waste would be segregated in the stockpiling area pending the results of waste characterization analysis. Excavation limits within each disposal area would initially be determined through visual observation, if possible, and subsequently confirmed through the collection of soil samples from the bottom and sidewalls of the excavations. Excavation will proceed to the bottom of sludge/waste (with concentrations in excess of PRGs) or to the designed depth within each excavation area.

The excavation would be conducted in stages to limit the size of open excavations, minimize delays related to confirmation sampling, and avoid disturbing important site features such as the sewer intercepter that runs along the western side of Areas 1 and 2. Once the final extent of excavation in an area (or sub-area) has been reached and confirmed, the excavation would be backfilled. Overlying soil would be loaded and hauled from the soil stockpiling area and used to backfill the bottom of the excavation. Clean, common fill would be imported to the site and used to complete the backfill of each excavation. The backfill would be placed, compacted, graded, and vegetated. At the conclusion of the removal action, a topographic survey would be performed to facilitate the preparation of as-built drawings.

Air monitoring for odorous sulfides, particulate matter, and other likely contaminants of concern would be performed on-site and at the site perimeter as needed, during the removal action to ensure that impacts to workers and neighboring residents are minimized. A detailed air monitoring plan, identifying contaminants of concern and monitoring/sampling methods, locations, and frequency will be developed prior to implementing the removal action. If air contaminants are detected during the removal action, emission control measures would be reassessed and modified as necessary.

v. <u>Transportation and Off-Site Disposal</u>

Once sludge/waste has been hauled to the stockpiling areas, engineering measures would be taken to prepare the sludge/waste for loading, transport, and disposal. Pretreatment measures such as the addition of drying agents and odor control agents, as discussed above, would be used to manage moisture and odor issues that would compromise transportation and disposal efforts.

Stockpile samples of sludge/waste would be collected at a rate of one sample per 500 tons for waste characterization. Subsequent to waste characterization analysis, stockpiled sludge/waste would be loaded onto 20-cubic yard dump trailers and transported to an EPA-approved off-site disposal facility.

It is assumed that waste characterization samples will confirm that sludge/waste is suitable for disposal at a RCRA Subtitle D landfill. However, for costing purposes under the EE/CA, cost scenarios have been evaluated for the potential that sludge from Area 1 is determined to be hazardous, requiring disposal at a RCRA Subtitle C (hazardous waste) landfill. Additionally, a hazardous waste determination for Area 1 sludge may also make applicable the RCRA land disposal standards for dioxin-containing waste (40 CFR 268-31), in which case disposal in a Canadian landfill would be the most viable disposal option. This option is addressed under a second contingency alternative. Land disposal considerations related to the classification of sludge/waste, and the implications they would have on the implementability and cost of Alternative 1 are discussed in Section 5.0.

vi. Site Restoration

Following completion of the excavation and backfill activities, cleared or denuded areas would be graded and revegetated by hydroseeding to reduce erosion and sediment transport.

vii. Flood Storage Capacity Restoration

All excavations would be backfilled to an elevation no higher than the original grade and at certain locations it may be appropriate to backfill to below the original grade. As a result, there would be no net increase in the elevation of the land surface resulting from the implementation of this alternative. Therefore, the flood storage capacity of the site would not be reduced and in fact may be increased if some of the areas within the floodplain are backfilled to a final elevation below the original grade.

viii. Post-Removal Site Control (PRSC)

The site would be inspected on a quarterly basis for the first 2 years (for EE/CA costing purposes) following the removal action. The site inspection would focus on the integrity of new vegetation and erosion controls.

4.5.2 Alternative 2 – Excavation and Consolidation into On-Site Landfill

Alternative 2 features the excavation and consolidation of contaminated sludge/waste into an on-site landfill. This alternative is similar to Alternative 1, except that sludge/waste is not transported to an off-site landfill, but consolidated on-site into a newly constructed landfill designed to meet all applicable state and federal requirements.

The design requirements for solid waste landfills (NH Env-Wm 2500) and hazardous waste landfills (RCRA Subtitle C) are very similar, both requiring a double liner, leachate collection and removal system, leak detection system, and stormwater management system. However, the criteria for hazardous waste landfills are somewhat more conservative, specifying a double leachate collection system, wind dispersal controls, and a construction quality control program. Because of the uncertainty of the final waste determination, the possibility that characterization sampling during excavation could result in portions of the sludge/waste being classified as hazardous, and the similarity in design requirements for solid and hazardous waste landfills, it was determined that the on-site landfill should be designed to meet the substantive requirements for both solid and hazardous waste landfills.

The key features of Alternative 2 are identified on Table 4-3. The Alternative 2 site implementation layout is depicted in Figure 4-2, and the conceptual design of the landfill liner and cover systems are presented on Figure 4-3. The following sections describe the key aspects of Alternative 2, with only those aspects that vary from Alternative 1 described in detail.

i. <u>Pre-Design Investigation (PDI)</u>

All of the components of the PDI that are mentioned in the description of Alternative 1 would be included in the PDI for Alternative 2. The effectiveness of moisture and odor control technologies would be the primary focus of the PDI, so that the on-site landfill would be compliant with all state and federal requirements and provide minimal impact to current and future neighboring residents.

ii. <u>Mobilization</u>

Personnel, equipment, materials, and subcontractors would be mobilized to the site as previously described for Alternative 1. Additional earth-moving equipment and materials would be mobilized to the site to construct the on-site landfill liner system and manage sludge/waste as it is placed into the landfill.

iii. <u>Site Preparation</u>

As mobilization of personnel, equipment, and materials to the site commences, site preparation activities would be implemented to prepare for the subsequent construction activities as described in Alternative 1. Similar to Alternative 1, a new site access road would be constructed to provide a direct route from the site to Broad Street and Route 3 for trucks delivering landfill construction materials to the site, and existing on-site roads would be graded and improved to facilitate loading and transportation of sludge/waste and soil throughout the site (Figure 4-2).

Additional site preparation activities unique to Alternative 2 include preparation of the area where the landfill will be located and construction of the landfill liner, which would be completed prior to any excavation activities. A more detailed description of the landfill construction is provided below.

iv. On-Site Landfill Construction

Prior to excavation of sludge/waste, a landfill liner system designed to meet applicable state and federal requirements for solid waste and hazardous waste landfills would be constructed as a consolidation cell for excavated media. The landfill would be sited in a manner that would comply with state and federal siting requirements, to the extent practicable, in order to minimize impacts to the environment and to current and future residents in the site vicinity. The area selected for landfill construction would be cleared, graded, and prepared to provide sufficient structural stability for the life of the landfill.

The on-site landfill would be underlain by a two-liner system designed to prevent any migration of wastes from the landfill to soil or groundwater in the adjacent area. Each liner would consist of a layer of low permeability soil overlain by a 60-mil high-density polyethylene (HDPE) liner. Primary and secondary leachate collection and removal systems would be constructed immediately above the upper and lower HDPE liners, respectively. These systems would be constructed of coarse-grained soil and sloped toward the perimeter of the landfill to facilitate the collection and removal of water that has passed through the sludge/waste layer. The secondary leachate collection and removal system, located immediately above the lower liner, would function as a leak detection system and would be utilized only in the event that the primary upper landfill liner has been breached. A visual depiction of the conceptual design of the landfill liner system is presented on Figure 4-3.

v. Excavation and Backfill

Excavation and backfill activities would be performed in the same manner, with the same quantity of sludge/waste, as described for Alternative 1. The only difference in operations would be that sludge/waste would not be hauled for off-site disposal, but instead hauled directly to the on-site landfill after the addition of any necessary amendments for moisture and odor control. As discussed for Alternative 1, a hazardous waste determination for sludge originating in Area 1 may trigger RCRA land disposal standards for dioxin-containing waste. In the event that waste characterization samples collected during the removal action indicate that sludge from Area 1 is governed by land disposal restrictions for dioxins, disposal in a Canadian landfill would be the most likely course of action. Land disposal considerations related to the classification of sludge/waste and the implications they would have on the implementability and cost of Alternative 2 are discussed in Section 5.0.

vi. Landfill Cover Construction and Site Restoration

Following the consolidation of site sludge/waste into the on-site landfill, the landfill would be capped to reduce leachate generation by limiting the infiltration of precipitation and/or surface water. A low permeability cover would be placed on top of the consolidated sludge/waste. The cover would be designed according to applicable standards to promote drainage of stormwater and other surface waters away from the landfill, limit erosion and sedimentation, control the release of odors, and prevent direct contact with consolidated material by future site users. The landfill cover would consist of a gas venting layer, a clay layer, a 60-mil HDPE liner, a soil cover, and a surface layer of topsoil vegetated to resist erosion. A visual depiction of the conceptual design of the landfill cover system is presented on Figure 4-3.

Following completion of excavation and backfill activities, cleared or denuded areas would be graded and revegetated by hydroseeding to reduce erosion and sediment transport. The final grade of the on-site landfill would be designed to blend with the surrounding topography. The perimeter of the on-site landfill would be fenced to prevent unauthorized entry, posted with signs, and secured at all access points.

vii. **<u>Flood Storage Capacity Restoration</u>**

Since the on-site landfill would not be constructed within the 100-year floodplain, it would not impact the flood storage capacity of the site. All excavations would be backfilled to an elevation no higher than the original grade and at certain locations it may be appropriate to backfill to below the original grade. As a result, there would be no net increase in the elevation of the land surface in the floodplain resulting from the implementation of this alternative. Therefore, the flood storage capacity of the site would not be reduced and in fact may be increased if some of the areas within the floodplain are backfilled to a final elevation below the original grade.

viii. **<u>Post-Removal Site Control (PRSC)</u>**

Subsequent to completion of the removal action, a post-closure care plan would be instituted to ensure the proper operation and maintenance of the landfill. The landfill would be inspected for evidence of deterioration or malfunction of run-off control systems or leachate collection and removal systems. Air sampling would be conducted to monitor air emissions from the landfill. Groundwater monitoring wells would be installed upgradient and downgradient of the landfill, and sampled periodically to assess the effectiveness of the landfill liner system. Other routine maintenance activities such as mowing, seeding, fertilizing, and repairing the landfill cover would also be part of the post-closure care plan. It is assumed that post-closure care activities would be performed on a monthly basis for the first 2 years, on a quarterly basis during years 3 to 5, and on a semi-annual basis thereafter. For costing purposes, it is assumed that the post-closure care period would be 30 years in duration.

The rest of the site would be inspected on a quarterly basis for the first 2 years following the removal action, as described for Alternative 1. This portion of the site inspection would focus on the integrity of new vegetation in the excavated areas and erosion controls.

4.5.3 Alternative 3 – Excavation, Off-Site Treatment and Disposal

Alternative 3 features the excavation and stockpiling of sludge/waste as described for Alternative 1. The difference between the two alternatives is that stockpiled sludge/waste would be loaded and transported to an off-site treatment, storage, and disposal facility (TSDF). Based on the screening of ex-situ treatment options, incineration would be the selected treatment method. Treatment residuals would be disposed of in a hazardous waste or solid waste landfill depending upon their hazardous waste characterization.

The key features of Alternative 3 are identified on Table 4-3. The Alternative 3 site implementation layout is depicted in Figure 4-1.

i. Pre-Design Investigation (PDI)

PDI activities required for Alternative 3 would be similar to those described for Alternative 1.

ii. Mobilization

Personnel, equipment, materials, and subcontractors would be mobilized to the site as previously described for Alternative 1.

iii. Site Preparation

As mobilization of personnel, equipment, and materials to the site commences, site preparation activities would be implemented to prepare for the subsequent construction activities as described in Alternative 1.

iv. Excavation and Backfill

Excavation and backfill activities and procedures would be the same as described for Alternative 1.

v. Transportation, Off-Site Treatment, and Disposal

As described for Alternative 1, engineering controls would be used to manage moisture and odor issues in the sludge/waste stockpile area. Sludge/waste would be loaded onto trucks and transported to an off-site TSDF, where it would be incinerated. Treatment residuals would be characterized and disposed of at the TSDF. For the purposes of this EE/CA, it is assumed that a domestic incinerator would be permitted and available to accept dioxin-containing waste. TtNUS has identified at least one U.S. facility that would accept such waste pending final characterization and waste determination. However, an alternative cost estimate has been provided for the case where a Canadian incinerator is the only available treatment option due to the dioxin content of sludge/waste and its RCRA characterization. A further discussion of the implementability and cost of Alternative 3 is presented in Section 5.0.

vi. <u>Site Restoration</u>

Following completion of the excavation and backfill activities, cleared or denuded areas would be graded and revegetated by hydroseeding to reduce erosion and sediment transport.

vii. <u>Flood Storage Capacity Restoration</u>

All excavations would be backfilled to an elevation no higher than the original grade and at certain locations it may be appropriate to backfill to below the original grade. As a result, there would be no net increase in the elevation of the land surface resulting from the implementation of this alternative. Therefore, the flood storage capacity of the site would not be reduced and in fact may be increased if some of the areas within the floodplain are backfilled to a final elevation below the original grade.

viii. <u>Post-Removal Site Control (PRSC)</u>

The site would be inspected on a quarterly basis for the first 2 years (for EE/CA costing purposes) following the removal action. The site inspection would focus on the integrity of new vegetation and erosion controls.

5.0 ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The analysis of alternatives provides information to facilitate the selection of a specific removal action option. The alternative analysis was developed in accordance with the EPA Guidance on Conducting NTCRAs under CERCLA (OERR Publication No. 9360.0-32, EPA/540-R-93) and the NCP. Section 5.1 provides an overview of the evaluation criteria used in the detailed analysis. Removal action alternatives are evaluated individually in Section 5.2. Section 5.3 presents a comparative analysis of removal alternatives. Section 5.4 presents the recommended removal action for the site.

5.1 Alternatives Evaluation Criteria

In conformance with the NTCRA guidance, the following three criteria and their components were used to evaluate each of the removal action alternatives developed in the previous section:

1. Effectiveness
   - overall protection of human health and the environment
   - compliance with ARARs
   - long-term effectiveness and permanence
   - reduction of toxicity, mobility, or volume through treatment
   - short-term effectiveness

2. Implementability
   - technical feasibility
   - administrative feasibility
   - availability of services and materials
   - state acceptance
   - community acceptance

3. Cost
   - direct and indirect capital costs
   - post-removal site control (PRSC) costs

5.2 Individual Analysis of Removal Action Alternatives

Three removal action alternatives were developed, as described in Section 4.0, to address contaminated sludge/waste located in Disposal Areas 1, 2, 3, 4, 6, and 7. Detailed evaluations of each alternative using the three criteria established above are presented in this section. The state and community acceptance criteria would be further addressed following receipt of comments during the public comment period.

As discussed in Section 4.0, each alternative was evaluated under various scenarios based on the hazardous waste classification of the sludge/waste or the location of the treatment facility. The Alternatives evaluated for the EE/CA are as follows:

Alternative 1 – Excavation and Off-Site Disposal

- 1A – All sludge/waste classified as non-hazardous
- 1B – Area 1 sludge classified as hazardous, land ban for dioxin-containing material not applicable
- 1C – Area 1 sludge classified as hazardous, land ban for dioxin-containing material applicable

Alternative 2 – Consolodation into On-Site Landfill

- 2A – All sludge/waste classified as non-hazardous
- 2B – Area 1 sludge classified as hazardous, land ban for dioxin-containing material not applicable
- 2C – Area 1 sludge classified as hazardous, land ban for dioxin-containing material applicable

Alternative 3 – Excavation, Off-Site Treatment, and Disposal

- 3-US – All sludge/waste treated at a U.S. incineration facility
- 3-CAN – All sludge/waste treated at a U.S. incineration facility

In the detailed analysis provided below, the sub-scenarios (e.g. 1B or 3-US) are cited where the waste classification or treatment facility location would have an impact on the specific evaluation criteria. In instances where regulatory status or treatment facility location does not impact the evaluation criteria, the evaluation refers to the removal action alternative in general (e.g. Alternative 1, 2, or 3).

5.2.1 Alternative 1 – Excavation and Off-Site Disposal

Alternative 1 features the excavation and off-site disposal of contaminated sludge/waste at an EPA-approved off-site landfill.

Effectiveness

Alternative 1 would meet the removal action objectives of this NTCRA by preventing direct contact and ingestion of contaminated sludge/waste, preventing ecological receptor exposure to contaminants, preventing the migration of contaminants to groundwater and surface water, and restoring the site to a condition suitable for residential use. These objectives would be achieved through excavation and off-site disposal of all sludge/waste containing concentrations of contaminants exceeding PRGs. This alternative would also be consistent with long-term remedial actions for this site.

Overall Protection of Human Health and the Environment – By removing all sludge/waste from the site that exceeds PRGs and replacing it with clean material, Alternative 1 would prevent direct contact with and ingestion of contaminated sludge/waste by human and ecological receptors at the site. The excavation and removal of sludge/waste from the site would also prevent migration of contaminants to groundwater and the Nashua River through leaching, flooding, or sediment transport, thus protecting the groundwater, surface water, river sediments, and biological receptors. Through the removal of sludge/waste exceeding PRGs, and implementation of site restoration activities, this alternative would restore the site to conditions suitable for residential use.

While Alternative 1 would not reduce, control, or eliminate risk through treatment, overall risks to human health and the environment would be reduced and controlled through off-site landfill disposal. EPA's Off-Site Rule (40 CFR 300.440) requires that an off-site facility selected for treating, storing, or disposing of hazardous substances, pollutants, and contaminants generated as the result of a CERCLA response action be fully compliant with RCRA or other applicable federal and state requirements. Of specific concern to EPA is the presence of "relevant releases or relevant violations at a facility prior to the facility's initial receipt of CERCLA waste". To ensure that contaminated sludge/waste is disposed of properly so that the NTCRA is protective of human health and the environment, this alternative would be implemented consistent with the Off-Site Rule.

Compliance with ARARs – Alternative 1 would be designed and implemented to comply with all federal and state ARARs. A summary of ARARs as they pertain to Alternative 1 is presented on Tables 5-1 through 5-3.

Long-Term Effectiveness and Permanence – Under Alternative 1, the leaching of contaminants to groundwater, impacts to the environment, and exposure of ecological and human receptors to contaminated sludge/waste would be eliminated as the result of excavation and off-site disposal of all sludge/waste containing contaminant concentrations above PRGs. Excavation and off-site disposal would be effective in the long term, would be permanent, and would contribute to future remedial objectives.

Implementation of Alternative 1 would require limited PRSC to ensure the integrity of revegetation, erosion and sediment controls.

Reduction of Toxicity, Mobility, or Volume Through Treatment – Because treatment of contaminated media is not a featured component of Alternative 1, there would not be any reduction in the toxicity, mobility, or volume of contaminated materials through treatment or recycling. Contaminated media would instead be consolidated and disposed of off site. While treatment is not a featured component, this alternative would effectively reduce the mobility of contaminants into groundwater and the Nashua River through removal.

Short-Term Effectiveness – Implementation of Alternative 1 would be expected to have limited short-term impacts to the local community, workers, and the environment. Short-term impacts during on-site activities would be expected to last approximately 11 months.

Increased heavy vehicle traffic into and out of the site would be expected along Fairmount Street during mobilization of equipment and construction of the temporary site access road.

Vehicular access into the site would be through the Fairmont Street entrance during this phase of the project. Impacts to local residences are expected to be minimal, and would last approximately two weeks.

Subsequent to access road construction, heavy vehicle traffic would be concentrated along the road adjacent to the gravel pit and Fimbel Landfill, onto the Fimbel Door Company property, and onto Broad Street and Route 3 during mobilization, site preparation, contaminated sludge/waste transport, wetland re-creation, site restoration, and demobilization. Heavy traffic along this route might cause some inconvenience to local residents, property tenants along the access route, and traffic patterns on Broad Street near the terminus of the access road. To reduce the potential for accidents and/or traffic congestion due to heavy vehicles merging into traffic on Broad Street, it may be necessary to post warning signs and use traffic control flagmen. To prevent unwanted off-site conveyance of contaminated sludge/waste by vehicles that have entered on-site work areas, the vehicle bodies, undercarriages, and tires would be pressure washed at a designated decontamination station each time they leave the Mohawk Tannery property.

Excavation of contaminated sludge within each disposal area may result in the release of offensive sulfide odors. While it is unlikely that the excavation of sludge will present a fugitive dust problem, the excavation of overlying soil or improvement of site roads may result in the release of fugitive dusts bearing dioxins, SVOCs, metals, and particulates. Sulfides, fugitive dust, and particulate emissions would be monitored during excavation activities and would be controlled or reduced using odor control agents, water sprays, or other engineering controls. Appropriate health and safety protocol, including using personnel protective equipment (PPE) and securing work areas, would be developed and implemented to protect workers and community residents from airborne contaminants and particulates.

As with any construction activity, an increase in noise levels during the removal action would be expected. Efforts would be made to minimize the potential impact to the local community by working during normal work-day hours and coordinating with the nearby residents, if necessary.

Implementation of Alternative 1 would have some short-term impacts to the environment. Excavation of sludge/waste in Areas 1 and 2 would occur along the Nashua River and within the 100-year floodplain. Erosion control measures along the river, such as silt fencing and hay bales, would be necessary during excavation activities to prevent the migration of contaminated soils. Revegetation of excavated areas following backfill would prevent erosion of the streambank.

Implementation of Alternative 1 would result in the temporary alteration of the 100-year floodplain, but would not result in any permanent loss of flood storage capacity. If it is determined to be appropriate to backfill some areas to below the original grade, there may in fact be an increase in flood storage capacity.

Implementability

The following is a discussion of the implementability of Alternative 1.

Technical Feasibility – Alternative 1 would be technically feasible, but there would be some technical challenges associated with excavation of sludge/waste and access to the site.

Some difficulties would be anticipated during the excavation of sludge/waste below the water table (Areas 1, 2, and possibly 3). Excavation below the water table presents potential problems including unstable excavation sidewalls, which leads to sloughing of contaminated material into the bottom of the excavation. This makes confirmation of the vertical limits of excavation extremely difficult to determine (both visually and through analytical sampling). More importantly, excavation below the water table could have significant adverse impacts on excavation rates, and increase the time required for excavation. Without the benefit of a full characterization of the aquifer, at the conceptual design stage, it is assumed that excavation would proceed at 75 percent of normally assumed production rates due to the anticipated impact of excavation below the water table in Areas 1 and 2. Unfavorable weather or hydrogeological conditions could potentially decrease production rates even further. Dewatering would be implemented during excavation to minimize impacts as much as possible.

Weather conditions and seasonal variations in groundwater levels would play a significant role in the ease of implementation of the alternative. Therefore, the period between late summer and early winter would be most favorable for the initiation of removal activities, due to the higher probability of cooler and drier weather and the assumption that the water table would likely be at its seasonal low.

Another technical challenge would involve excavation of sludge/waste in the vicinity of the sewer interceptor that runs along the western side of Areas 1 and 2. Care would have to be taken during excavation to prevent damage to the sewer line. Accurate surveying and marking of the location of the interceptor and careful planning and execution of excavation in these areas would mitigate impacts. It is assumed that sludge/waste does not extend beneath the sewer line. Any sludge that does extend beneath the interceptor may have to be left in place to avoid structural damage to the line.

Another technical challenge will be controlling odors and moisture during the excavation and handling of sludge/waste. A PDI may be required prior to initiating sludge/waste excavation. The PDI could be used to aid in the selection and design of engineering controls that would be used to control odors and moisture during the excavation and handling of sludge/waste, including stockpiling activities and transportation to the disposal facility. No technical difficulties are anticipated with the implementation of the PDI. Use of data from a PDI would help minimize odor and moisture control problems during implementation.

Site access is an important technical consideration for Alternative 1. Currently, the only vehicle access point to the site is through the truck gate at the terminus of Fairmont Street. Access to Fairmont Street from Route 3 requires travel through densely populated residential neighborhoods. In order to implement Alternative 1, a temporary site access road would be constructed from Broad Street, alongside the Fimbel Door Company building, adjacent to the Fimbel Landfill, and entering the site from the north adjacent to Area 5. Construction of the access road would be technically feasible, provided that property access agreements were reached with landowners located along the proposed route for the access road.

Another technical consideration for Alternative 1 is the proximity of the Nashua River. Because Area 2 is located within the 100-year floodplain and is subject to flooding; if possible, removal activities would be restricted to seasons with low flooding probability to reduce potential migration of contaminated sludge/waste during excavation activities and to protect on-site workers.

Administrative Feasibility – Although permits would not be required for any of the site preparation and excavation activities because these activities would be performed at a site under CERCLA initiative, all removal actions would be performed to comply with the substantive requirements of all ARARs. Coordination with the NHDES would be necessary for on-site activities. Coordination with local municipal representatives would be required to initiate discharge of dewatering effluent to the City sewer system and to determine appropriate measures to reduce traffic impacts along Broad Street at the outlet of the temporary site access road. Coordination with landowners along the proposed access route would be required to construct and utilize the temporary site access road.

In April of 2002, the NHDES completed an updated hazardous waste determination for site sludge/waste using data gathered during the EE/CA field investigation. The data and the NHDES determination support the assumption that sludge/waste from the site would not be considered a RCRA hazardous waste. However, the regulatory determination could change based on the results of the waste characterization samples collected from sludge/waste stockpiles during excavation. As discussed above, three potential scenarios were evaluated to analyze the impact of a hazardous waste classification. Alternative 1A was developed under the assumption that all excavated sludge/waste would be determined to be non-hazardous and suitable for disposal at a RCRA Subtitle D landfill facility. Alternative 1B was created to evaluate the implementability and cost of the disposal of Area 1 sludge at a RCRA Subtitle C landfill, which would be the required disposal option for waste characterized as hazardous but not subject to 40 CFR 268.31 (Waste-Specific Prohibitions – Dioxin-Containing Wastes). Alternative 1C was created to evaluate the implementability and cost of the disposal of Area 1 sludge at a Canadian landfill, which would be the required disposal option for waste characterized as hazardous and subject to 40 CFR 268.31, land disposal restrictions for dioxin-containing wastes.

From an administrative standpoint, Alternatives 1A and 1B would be similarly implementable. All of the administrative requirements for transportation and off-site disposal of waste at an

American landfill could easily be met. Alternative 1C would be implementable, but more difficult than Alternatives 1A and 1B due to permitting and compliance issues associated with international transport of hazardous waste.

Availability of Services and Materials – Companies with the trained personnel, equipment, and materials to perform all necessary earth moving, demolition, excavation, dewatering, and backfilling activities are readily available. Since contaminated materials are to be handled, trained personnel would be required. Mobile laboratory facilities with 24-hour sample turnaround time capabilities are available to handle the analytical requirements of the alternative. All proposed aspects of the removal action could be bid competitively.

Qualified off-site disposal facilities, in compliance with EPA's Off-Site Rule, have been identified during the EE/CA preparation. Sludge/waste that is characterized as solid waste would be transported and disposed of at one of several potential Subtitle D landfill facilities. Sludge/waste that is characterized as hazardous, but not subject to the land disposal ban, would be transported and disposed of at a RCRA Subtitle C disposal facility. Sludge/waste that is subject to the land disposal ban for dioxin-containing wastes would be transported to a Canadian facility. Subtitle C landfills and Canadian landfills capable of accepting site sludge/waste are available, and have been identified during preparation of the EE/CA.

State Acceptance – The State of New Hampshire has been involved in the development of removal alternatives for the EE/CA. The state's acceptance and comments on this alternative will be evaluated following the public comment period.

Community Acceptance – Community acceptance will be considered based on comments received during the public comment period for EPA's proposed removal action alternative, prior to selecting the removal action in the Action Memorandum.

<u>Cost</u>

Based on the assumptions presented in Section 4 and detailed in Appendix L, the capital costs for Alternative 1A are estimated to be approximately $14,939,000; the PRSC costs for the first two years are $4,000 per year; and the total present worth costs are approximately

$14,946,000. This cost estimate was based on the assumption that final waste determination and analytical results of waste characterization samples collected from stockpiles would indicate that sludge/waste is suitable for disposal at a RCRA Subtitle D facility.

Alternative cost estimates were generated to analyze the additional costs that would be incurred should sludge from Area 1 be characterized as hazardous waste. The capital costs of Alternative 1B ($20,428,000) represent the estimated capital costs for disposal of sludge/waste from Area 1 at a RCRA Subtitle C disposal facility. The difference in cost between Alternatives 1A and 1B is attributed to increases in transportation and disposal costs for the hazardous portion of sludge/waste (Area 1). The capital costs of Alternative 1C ($22,819,000) represent the estimated capital costs for disposal of sludge/waste from Area 1 at a Canadian landfill facility. The additional costs for Alternative 1C are attributed to increased transportation and disposal costs and the permitting requirements associated with disposal at a Canadian landfill. Assuming PRSC cost schedules identical to those for Alternative 1A, the total present worth costs for Alternatives 1B and 1C would be approximately $20,435,000 and $22,826,000, respectively.

Total present worth costs were calculated using a 7 percent discount rate in accordance with OSWER directive No. 9355.3-20, June 25, 1993.

5.2.2 Alternative 2 – Consolidation into On-Site Landfill

Alternative 2 features the excavation of contaminated sludge/waste from Disposal Areas 1, 2, 3, 4, 6, and 7; and the consolidation of excavated material into a newly constructed on-site landfill. As discussed in Section 4.5.2, the on-site landfill would be designed and constructed to meet applicable state and federal requirements for solid waste and hazardous waste landfills.

<u>Effectiveness</u>

Alternative 2 would meet the removal objectives of this NTCRA by preventing direct contact and ingestion of contaminated sludge/waste, and preventing continued ecological and environmental impacts from the release of contaminants into groundwater and the Nashua

River. This alternative would only partially satisfy the future site use removal objective by consolidating sludge/waste into a designated, controlled disposal area, and allowing the remainder of the site to be used for residential purposes. This alternative would be consistent with the removal action objectives for the site and the long-term remedial actions for the site.

Overall Protection of Human Health and the Environment – Alternative 2 would prevent direct contact with and ingestion of contaminated sludges and soils by human and ecological receptors by excavating and consolidating sludge/waste exceeding PRGs into an on-site landfill, and replacing it with clean soil. The removal of sludge/waste from the Disposal Areas would prevent the migration of contaminants to the Nashua River through flooding and sediment transport, thus protecting the surface water, river sediments, and biological receptors. The on-site landfill would include design elements and long-term maintenance that would prevent direct contact with sludge/waste and migration of contaminants from sludge/waste to groundwater and the Nashua River. The long-term protection of human health and the environment provided by this Alternative would depend on adequate long-term maintenance of the landfill and enforcement of permanent restrictions on use of the landfill area.

Compliance with ARARs – Alternative 2 would be designed and implemented to comply with all federal and state ARARs. A summary of ARARs as they pertain to Alternative 2 is presented on Tables 5-4 through 5-6.

Long-Term Effectiveness and Permanence – Under Alternative 2, risks to human health and the environment due to contact with sludge/waste would be reduced in the long-term, provided that the on-site landfill cap is properly operated and maintained. An estimated 60,000 cubic yards of sludge/waste would remain on site, but would be consolidated into an engineered landfill designed to contain sludge/waste. Institutional controls, if implemented and enforced, would restrict or prohibit landfill access that may impair the integrity of the cap or result in bringing contaminated materials above the cap.

Alternative 2 would be effective in the long term in meeting removal objectives and would constitute a permanent solution, assuming that the landfill were properly operated and maintained. However, in order to ensure the long-term effectiveness of the remedy, this alternative requires that permanent restrictions be placed on how the landfill-portion of the site could be used, thereby limiting the future use and development of these portions of the site. If the landfill cap were damaged, contaminants could pose risks to human and ecological receptors.

Under Alternative 2, PRSC would be needed to ensure the integrity of revegetation, erosion and sedimentation controls. Additionally, long-term monitoring and maintenance of the landfill would be required to ensure the effectiveness of the landfill as a containment cell. A post-closure care program outlining the operations and maintenance schedule would need to be developed and approved by the State in order to achieve this goal. The landfill is potentially viable in the long-term and may not require replacement if maintenance is continual. Imposition and enforcement of deed restrictions and long-term monitoring and maintenance of the landfill would be required to maintain the long-term effectiveness of this alternative. Long-term groundwater monitoring would be included as part of the post-closure care program and would be used to analyze the effectiveness of the landfill.

No difficulties or uncertainties are anticipated in performing the long-term maintenance. All materials to be used are readily available and can be replaced. If the landfill was damaged, repairs would likely be performed without difficulty.

Reduction of Toxicity, Mobility, or Volume Through Treatment – Because treatment of contaminated media is not a featured component of Alternative 2, there would be no reduction in the toxicity, mobility, or volume of contaminated materials through treatment or recycling. However, the consolidation of sludge/waste into the on-site landfill would reduce the ability of contaminants to migrate into groundwater and surface water bodies.

Short-Term Effectiveness – Implementation of Alternative 2 would be expected to have limited short-term impacts to the local community, on-site workers, and the environment.

As discussed in the analysis of Alternative 1, increased truck traffic, odor and dust emissions during sludge/waste excavation and handling, and noise would be the primary short-term concerns. Short-term impacts to the environment, such as temporary alteration of the 100-year floodplain would also occur. Engineering controls would be implemented to minimize these impacts, as outlined in the detailed analysis of Alternative 1.

The estimated site time needed to complete Alternative 2 would be approximately 16 months.

Implementability

The following is a discussion of the implementability of Alternative 2.

Technical Feasibility – Alternative 2 would be feasible and moderately complex. All of the same technical difficulties identified for Alternative 1 would apply to the implementation of Alternative 2.

Additional technical considerations unique to Alternative 2 would include designing the landfill to provide minimal impact to the local community. Due to space restrictions at the site, the gravel pit would be the most feasible location for the on-site landfill. However, due to the volume of sludge/waste to be excavated, a 30- to 40-foot sludge/waste thickness would be required because of the space restrictions in this area of the site. Depending on final determination of the mean high water level (which dictates the lowest possible elevation of the landfill liner), it is possible that construction of an on-site landfill of the required size would result in unacceptable changes in site topography. Of specific concern would be possible visual/aesthetic impacts of the landfill to neighboring residents.

Administrative Feasibility – The primary administrative issue confronting the implementation of Alternative 2 would be coordination with NHDES for approval to construct the on-site landfill. The proximity of the site to a residential neighborhood and to the Nashua River may complicate the process and require extra time and effort.

Assuming that all of the necessary approvals could be obtained for the on-site landfill, a secondary issue that may arise is the potential effect of a hazardous waste determination for

Area 1 sludge. As discussed in the detailed analysis for Alternative 1, the possibility exists that final waste determination would require Area 1 sludge to be handled as a hazardous waste. Under scenario B (hazardous waste, no land ban), Area 1 sludge/waste would still be suitable for on-site landfill disposal, since the landfill would be designed to meet RCRA Subtitle C (hazardous waste) standards. However, under regulatory scenario C (hazardous waste, land ban applicable), Area 1 sludge would have to be disposed of at an off-site location outside of the United States. Therefore, Alternative 2C was created to evaluate the implementability and cost of transporting Area 1 sludge to a Canadian landfill. From an administrative standpoint, Alternative 2C would be implementable, but more difficult than Alternatives 2A and 2B due to permitting and compliance issues associated with the international transport of hazardous waste.

As discussed for Alternative 1, permits would not be required for any of the site preparation and excavation activities because these activities would be performed at a site under a CERCLA initiative. Coordination with the EPA, NHDES, and local municipal representatives would be required to facilitate implementation of Alternative 2. Coordination with other agencies and property owners along the route of the site access road would be required to construct and utilize the temporary site access road.

Availability of Services and Materials – As discussed in the detailed analysis of Alternative 1, several contractors are available to implement all aspects of the site work that would be required for the alternative. Several contractors and the necessary materials are also available to construct the on-site landfill. At least one Canadian landfill has been identified as a potential disposal option for Area 1 waste, should implementation of Alternative 2C be required.

State Acceptance – The State of New Hampshire has been involved in the development of removal alternatives for the EE/CA. The state's acceptance and comments on this alternative will be evaluated following the public comment period.

Community Acceptance - Community acceptance will be considered based on comments received during the public comment period for EPA's proposed removal action alternative, prior to selecting the removal action in the Action Memorandum.

Cost

Based on the assumptions presented in Section 4.0 and detailed in Appendix L, the capital costs for Alternatives 2A and 2B are estimated to be $5,572,000; the PRSC costs for the first year are $155,275; and the total present worth costs are approximately $6,300,000.

Alternative 2C capital costs were estimated to be $18,428,000, with a PRSC cost schedule assumed to be the same as for Alternative 2A and a present worth of approximately $19,156,000. Additional costs for Alternative 2C are attributed to transportation and disposal costs for Area 1 waste at the Canadian landfill, which outweighed the cost savings realized from the reduction in on-site landfill capacity.

Total present worth costs were calculated using a 7 percent discount rate in accordance with OSWER directive No. 9355.3-20, June 25, 1993.

5.2.3 Alternative 3 – Excavation, Off-Site Treatment, and Disposal

Alternative 3 features excavation of contaminated sludge/waste and off-site treatment and disposal at an EPA-approved incineration facility. Alternative 3 is similar to Alternative 1, except that contaminated sludge/waste would be transported to an off-site incinerator and treated prior to disposal, rather than transported to an off-site landfill and disposed of without treatment. A change in regulatory status of site sludge/waste would not have significant impacts on the implementation of this alternative, but the availability of treatment facilities capable of accepting dioxin-containing waste would have implementation impacts. Therefore, off-site treatment and disposal options utilizing a treatment facility in the United States (Alternative 3-US) and Canada (Alternative 3-CAN) have been evaluated.

Effectiveness

Alternative 3 would meet the removal objectives of this NTCRA by preventing direct contact and ingestion of contaminated sludge/waste, and preventing continued ecological and environmental impacts from the release of contaminants into groundwater and the Nashua River. This alternative would also satisfy the future site use removal objective. This alternative would be consistent with the removal action objectives for the site and the long-term remedial actions for the site, and would satisfy the statutory preference for treatment over disposal.

Overall Protection of Human Health and the Environment – Alternative 3 would provide short-term and long-term protection of human and ecological receptors from direct contact exposures to contaminated sludge/waste exceeding PRGs. Alternative 3 would also provide long-term protection of human health and the environment by preventing the migration of contaminants to groundwater and the Nashua River through leaching, flooding, or sediment transport. Through the removal of sludge/waste exceeding PRGs and implementation of site restoration activities, this alternative would restore the site to conditions suitable for residential use. Alternative 3 would be implemented in compliance with EPA's Off-Site Rule.

Compliance with ARARs – Alternative 3 would be designed and implemented to comply with all federal and state ARARs. A summary of ARARs as they pertain to Alternative 3 is presented on Tables 5-7 through 5-9.

Long-Term Effectiveness and Permanence – Under Alternative 3, impacts to the environment and exposure by ecological and human receptors to contaminated sludge/waste would be eliminated as the result of excavation, treatment, and off-site disposal of all sludge/waste containing contaminant concentrations above PRGs. Excavation, off-site treatment, and disposal would be effective in the long term, would be permanent, and would contribute to future remedial objectives.

Implementation of Alternative 3 would require limited PRSC to ensure the integrity of new vegetation, erosion and sediment controls, and wetland re-creation.

Reduction of Toxicity, Mobility, or Volume Through Treatment – Alternative 3 would reduce the toxicity, mobility, and volume of contamination through the destruction of contaminants during the incineration process. Incineration of contaminated sludge/waste would be required by regulation 40 CFR 264, Subpart O to provide a 99.9999% reduction in total dioxins and a 99.99% reduction in total SVOCs. Incineration is likely to result in greater than 50 percent volume reduction prior to disposal. Residual ash containing concentrations of metals may need to be stabilized to reduce their mobility and toxicity prior to disposal. The mobility of metal constituents would be reduced to regulatory limits specified under 40 CFR 261.24.

Short-Term Effectiveness – Short-term effectiveness concerns of Alternative 3 would be identical to those described in the detailed analysis of Alternative 1, since on-site activities performed under the two alternatives would be the same.

<u>Implementability</u>

The following is a discussion of the implementability of Alternative 3.

Technical Feasibility – On-site technical feasibility issues for Alternative 3 would be identical to those discussed in the detailed analysis of Alternative 1, since on-site activities performed under the two alternatives would be the same. Incineration has been proven effective in treating contaminated media with similar physical and chemical characteristics as those observed at the site.

Administrative Feasibility – Although permits would not be required for any of the site preparation and excavation activities because these activities would be performed at a site under a CERCLA initiative, all removal actions would be performed to comply with the substantive requirements of all ARARs. Coordination with NHDES would be necessary for on-site activities. Coordination with local municipal representatives would be required to initiate discharge of dewatering effluent to the City sewer system and determine appropriate measures to reduce traffic impacts along Broad Street.

Administrative approvals would be required for the off-site treatment and disposal of the contaminated sludge/waste. Depending on the availability of U.S. incineration facilities willing to receive dioxin-containing waste, obtaining such approvals may be difficult. Approvals for international off-site treatment and disposal would be feasible, but would require additional time and effort.

Availability of Services and Materials – As discussed for Alternative 1, there are several companies available with the personnel, equipment, and materials to perform all of the necessary site work required for this alternative. Sufficient contractors would be available for competitive bidding.

TtNUS identified at least one qualified off-site treatment and disposal facility within the United States that is able to accept dioxin-contaminated waste, although the availability of such facilities nationwide is extremely limited. For this reason, an incineration facility in Canada was identified as a potential alternative should incineration options in the U.S. not become available.

State Acceptance – The State of New Hampshire has been involved in the development of removal alternatives for the EE/CA. The state's acceptance and comments on this alternative will be evaluated following the public comment period.

Community Acceptance – Community acceptance will be considered based on comments received during the public comment period for EPA's proposed removal action alternative, prior to selecting the removal action in the Action Memorandum.

<u>Cost</u>

Based on the assumptions presented in Section 4.0 and detailed in Appendix L, the capital costs for Alternative 3-US are estimated to be $69,715,000; the PRSC cost schedule for Alternative 3-US would be the same as detailed for Alternative 1, and would result in total present worth costs of approximately $69,722,000.

Alternative 3-CAN, which would involve treatment and disposal at a Canadian incinerator, would involve capital costs of approximately $50,152,000 with a total present worth cost of approximately $50,160,000. The PRSC costs would be the same as for Alternative 3-US.

Total present worth costs were calculated using a 7 percent discount rate in accordance with OSWER directive No. 9355.3-20, June 25, 1993.

5.3 Comparative Analysis of Removal Action Alternatives

As part of the alternatives analysis, the removal action alternatives evaluated individually above were compared in order to identify differences between the alternatives and to analyze their comparative benefits and drawbacks. Generally, all alternatives offer similar degrees of protection and would achieve all of the removal action objectives established for this NTCRA. For each of the three alternatives, no residual contamination would remain at the site that would pose a risk to human health or the environment once the removal action was completed. Alternatives 1 and 3 would not require PRSC operations to maintain the protectiveness of the alternative, except for monitoring of site restoration measures until the actions satisfy applicable federal and state standards. Alternative 2, unlike Alternatives 1 and 3, would consolidate and contain contaminated sludge/waste on site rather than remove it from the site and would require more extensive PRSC to monitor the integrity of the on-site landfill and prevent impacts to human health and the environment. In addition, the placement of wastes in an on-site landfill under Alternative 2 would restrict the future use and development of the site to a greater extent than for Alternatives 1 and 3. Table 5-10 presents a summary of the alternatives evaluation that is presented in the following text.

5.3.1 Effectiveness

The following is a comparative analysis of the effectiveness of each of the three removal action alternatives analyzed for the EE/CA.

Overall Protection of Human Health and the Environment

Alternatives 1, 2, and 3 would all meet the removal action objectives of this NTCRA because all contaminated sludge/waste that exceeds the proposed PRGs would be removed, contained, or treated. Alternative 2 would not be as effective as Alternatives 1 and 3 in meeting the future residential site use objective since Alternative 2 would leave wastes on site, thereby restricting how the landfill area could be developed and used in the future. The time to achieve removal objectives for Alternatives 1 and 3 would be approximately 17 months from initiation of design through demobilization from the site. Alternative 2 would require additional time for design and on-site implementation, with a total project duration of approximately 26 months.

Compliance with ARARs

Alternatives 1, 2, and 3 would all be designed and implemented to comply with ARARs. Each alternative involves collection of water generated from dewatering the Area 1 lagoon, groundwater infiltration during excavation, and free liquids from stockpiled sludge/waste, and discharging to the Nashua sewer system. These alternatives would be implemented to comply with state and federal regulations concerning discharge to wastewater treatment plants.

During implementation, the three alternatives would comply with federal testing and waste identification requirements, the New Hampshire Solid Waste Management requirements and state air pollution control requirements. Alternative 2 would also follow relevant and appropriate federal and state regulations for landfill closure and post-closure care.

Long-Term Effectiveness and Permanence

Alternatives 1 and 3 would be effective in the long term and would be permanent because all contaminated sludges and soils exceeding PRGs would be removed from the site. Alternative 2 would be effective in the long term and would be permanent, provided that the landfill is properly operated and maintained and is not allowed to erode or degrade. If the landfill is damaged or breached, and the cap or liner is allowed to erode or degrade, contaminants could leach into groundwater, migrate by erosion or runoff, or pose direct exposure risks to human and ecological receptors. Alternative 2 would require enforcement of access and use restrictions for the landfill area and would require additional PRSC measures over those proposed for Alternatives 1 and 3 to ensure the effectiveness of the removal action.

Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 1 and 2 would not employ treatment. Alternative 3 would achieve a 99.9999 percent destruction and removal efficiency (DRE) for total dioxins and a 99.99% DRE for total SVOCs (per federal regulations) and a greater than 50 percent reduction in volume. Air emissions from the incineration process would be treated, and solid phase treatment residuals would be stabilized, if necessary, to limit mobility of contaminants in sludge/waste. Alternative 3 would satisfy the statutory preference for treatment, while Alternatives 1 and 2 would not.

Short-Term Effectiveness

There would be limited impacts to on-site removal workers, the local community, and the environment during the implementation of Alternatives 1, 2, and 3. For the three alternatives, monitoring for sulfide odors and other potential contaminants of concrern (particulate matter, dioxins, SVOCs, and metals) would be performed as needed, and appropriate engineering controls would be used to minimize or prevent adverse impacts. On-site air emissions concerns would be similar for Alternatives 1 and 3, and slightly greater for Alternative 2 due to the increased onsite handling of sludge/waste during construction of the landfill. All three alternatives would include erosion and sediment controls and other management controls to prevent contaminated sludges and soils from migrating into the Nashua River during removal activities.

Increased noise and vehicular traffic would be anticipated under all three alternatives. Implementation of Alternative 2 would result in less vehicular traffic to and from the site since transport of sludge/waste would not be part of the removal action.

Alternatives 1 and 3 have similar on-site removal action durations (11 months). Landfill construction activities that would be implemented under Alternative 2 would require additional time and would result in an estimated 16-months of on-site removal action activities. Figure 5-1 provides a comparison of anticipated project duration for each of the three removal action alternatives.

5.3.2 Implementability

The following is a comparative analysis of the implementability of the three removal action alternatives analyzed for the EE/CA.

Technical Feasibility

All three alternatives would be technically feasible, but some difficulties would be expected. No technical difficulties are anticipated for site preparation and site restoration activities since common construction techniques and equipment are required. Excavation of sludge/waste located below the water table and near the sewer interceptor would present difficulties, but they would be the same for each alternative. Landfill construction techniques and equipment are readily available (for Alternative 2). Access, spatial limitations, and odor and moisture control issues could be overcome through the use of a well-developed site management plan.

Spring flooding and summer weather conditions would be expected to complicate the implementation of all three alternatives. Odor and moisture control concerns would be less likely to be problematic if the removal action were implemented in cooler, drier weather and during periods of seasonal low groundwater.

Administrative Feasibility

Actual permits are not required for on-site work but the substantive requirements of any ARARs would be addressed and met for work performed under all alternatives. However, administrative approvals would be required for off-site transport and disposal of contaminated sludge/waste (Alternatives 1A, 1B, 1C, and 2C) or off-site transport, treatment, and disposal of sludge/waste (Alternatives 3-US and 3-CAN). Alternative 2 would require coordination with NHDES to satisfy all requirements for the construction of the on-site landfill.

The administrative feasibility of each alternative depends largely on the final waste determination for Area 1. A hazardous waste determination would make each alternative administratively more difficult. But regardless of the final waste determination or waste characterization during excavation, Alternative 1 could be implemented with the least administrative difficulty. Acquisition of landfill approvals for off-site disposal of sludge/waste—whether at a RCRA D, RCRA C, or Canadian facility—would be easier from an administrative standpoint than obtaining concurrence and acceptance from the State and public to construct an on-site landfill (Alternative 2) or obtain administrative approval for off-site incineration (Alternative 3).

Availability of Services and Materials

Qualified contractors with trained personnel, equipment, and hazardous waste site experience would be readily available to perform all of the on-site services that would be required for all three alternatives. RCRA D, RCRA C, and Canadian landfills have been identified that would have the off-site disposal capacity to receive the anticipated volume of contaminated sludge/waste, but final decisions on the ability or willingness of these facilities to accept site sludge/waste could not be made at the time of the EE/CA preparation.

Availability of a qualified off-site incineration facility within the United States that is capable of receiving dioxin-containing waste is expected to be limited. At least one such facility was identified during preparation of the EE/CA, but final decisions on the ability or willingness to accept site sludge/waste could not be made at the time of the EE/CA. The option of using a Canadian facility (Alternative 3-CAN) is available and was evaluated as an alternative off-site treatment option in the case that no U.S. incinerator would accept sludge/waste from the site.

State Acceptance

This factor will be addressed after the close of the public comment period.

Community Acceptance

This factor will be addressed after the close of the public comment period.

5.3.3 Cost

Summaries of the costs for each alternative are presented in Table 5-10, along with the implications of final waste determination or characterization during implementation. If the entire volume of sludge/waste were to be classified as non-hazardous waste, Alternative 2 would be the least expensive, followed by Alternative 1, then Alternative 3-CAN and Alternative 3-US. If Area 1 sludge were to be classified as hazardous waste but not governed by the land disposal ban on dioxin-containing materials, the difference in cost between Alternatives 1 and 2 would widen, with Alternative 1 costs increasing and Alternative 2 costs remaining the same.

The cost of Alternatives 3-CAN and 3-US would not change, but would still be the most expensive. If Area 1 sludge were to be classified as hazardous and governed by the land disposal ban, Alternative 2 would still be the least expensive option, followed by Alternative 1, but the difference in costs would be considerably smaller. Alternatives 3-Can and 3-US would still be considerably more expensive than either of the other Alternatives. PRSC costs for Alternatives 1 and 3 are the same. The PRSC costs for Alternative 2 are greater than those for Alternatives 1 and 3, under all potential regulatory scenarios, due to the need for long-term post-closure care of the on-site landfill.

5.4 Recommended Removal Alternative

Based on the comparison of alternatives, Alternative 1 was selected as the recommended removal alternative. All alternatives met the NTCRA removal objectives and were protective of human health and the environment. Alternatives 1 and 3 fully satisfied the removal objective of restoring the site for future residential use; Alternative 2 only partially satisfied this removal objective since Alternative 2 would leave wastes on site in an on-site landfill, thereby restricting how the landfill area could be developed and used in the future. Although Alternatives 1 and 3 constituted a more permanent measure due to fewer PRSC requirements, all alternatives may be considered permanent and would be effective in the long term provided that the on-site landfill (in Alternative 2) is properly operated and maintained and land use restrictions are enforced. Only Alternative 3 would satisfy the statutory preference for treatment.

The primary differences among the three alternatives lie in their implementability. Alternative 1 would be the most easily implemented. Several off-site landfill facilities in reasonably close proximity to the site are available to accept the volume of sludge/waste that is expected to be generated during the removal action. In addition, obtaining the necessary approvals for the off-site landfill disposal alternative is expected to present the fewest challenges from an administrative feasibility standpoint.

Alternative 2 would be much more challenging to implement than Alternative 1 due to the size of the on-site landfill that would be required to accommodate the volume of contaminated sludge/waste at the site and the potential for public opposition to an on-site landfill. Design and construction of an on-site landfill that would be adequate to encapsulate 66,000 cubic yards of material would place considerably more constraints on how the site could be used and developed in the future and require more long-term efforts associated with PRSC. As a result, obtaining concurrence and acceptance from the State and public to construct an on-site landfill may be difficult.

Alternative 3 would be more difficult to implement than Alternative 1 because of the limited number of off-site incineration facilities within the U.S. and Canada that are permitted to receive dioxin-containing waste. Alternative 3 would be easier to implement than Alternative 2 because locating available incineration facilities and obtaining the necessary approvals for off-site incineration would present fewer challenges than obtaining concurrence and acceptance from the State and public to construct a landfill at the site.

Although Alternative 1 is only slightly more implementable than Alternative 3, it was selected as the preferred alternative because it would be considerably less costly. Off-site treatment at a Canadian incinerator (Alternative 3-CAN) would be the least expensive treatment option, but would still cost over three times more than off-site disposal, if Area 1 sludge were classified as non-hazardous waste; and more than two times more than off-site disposal if Area 1 sludge were classified as hazardous waste. For this reason, Alternative 1 (A, B, or C) is selected as the preferred removal action alternative, pending final waste determination and/or characterization results.

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